



**PLEASE CHECK FOR CHANGE INFORMATION
AT THE REAR OF THIS MANUAL.**

AFG 5101/AFG 5501
Programmable
Arbitrary/Function
Generator

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077
070-6759-00
Product Group 75

Serial Number _____

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INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag,
or stamped on the chassis. The first number or letter
designates the country of manufacture. The last five digits
of the serial number are assigned sequentially and are
unique to each instrument. Those manufactured in the
United States have six unique digits. The country of
manufacture is identified as follows:

8000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektonix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

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WARNING

The following servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing other than that contained in operating instructions unless you are qualified to do so. Refer to Operators Safety Summary prior to performing any service.

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OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary. Safety information applies to both the AFG 5101 and AFG 5501 unless noted otherwise.

TERMS

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

SYMBOLS

In This Manual



This symbol indicates where applicable cautionary or other information is to be found.

As Marked on Equipment



DANGER—High voltage.



Protective ground (earth) terminal.



ATTENTION—refer to manual.

Power Source

This product is intended to operate from a power module connected to a power source (AFG5101) or from a power source (AFG 5501) that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power module power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power module power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Power Cord (AFG 5501)

Use only the power cord and connector specified for your product. Use only a power cord that is in good condition. For detailed information on power cords and connectors, see maintenance section. Refer cord and connector changes to qualified service personnel.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating and current rating as specified in the Specifications or parts list for your product. Refer fuse replacement to qualified service personnel.

OPERATORS SAFETY SUMMARY (Cont)

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Operate Without Covers

To avoid personal injury, do not operate this product without covers or panels installed. Do not apply power to the plug-in via a plug-in extender.

SERVICE SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operator Safety Summary.

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing With Power On

Dangerous voltages may exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

This product is intended to operate in a power module connected to a power source (AFG 5101) or from a power source (AFG 5501) that will not apply more than 250 volts rms between the supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

SPECIFICATION

Introduction

This section of the manual contains a general description of the Tektronix AFG 5101/5501 Programmable Arbitrary/Function Generator and complete electrical, environmental, and physical specifications. Standard accessories are also listed.

Instrument Description

The AFG 5101/5501 Programmable Arbitrary/Function Generator is an analog signal source for sine, triangle, square, arbitrary, and dc signals. The AFG 5101 is designed to operate in three compartments of a TM 5000 Series power module. The AFG 5501 is a monolithic version of the AFG 5101.

NOTE

Information in this manual applies to both the AFG 5101 and AFG 5501 unless otherwise noted.

The AFG5101/5501 can be operated manually using front panel keys, or programmed via the general purpose interface bus (GPIB). Recommended controllers are the Tektronix 4041; or an IBM PC-compatible, such as the Tektronix PEP 301, with the Tektronix GURU software and GPIB interface card. When properly installed, the AFG 5101/5501 is compatible with other instruments that meet IEEE Standard 488-1978.

For standard waveform functions, the AFG 5101/5501 operates within a frequency range of 0.012 Hz to 12 MHz. For all waveform functions, output amplitude is from 10 mV to 9.99 V p-p into 50 ohms. Output can be in continuous, triggered, gated, or burst mode.

Arbitrary waveforms can be generated with 12-bit resolution; these can be generated discretely from user-defined data, or by using one of five internal, predefined waveforms, or a combination of these. Two non-volatile memory banks (8192 points each) store arbitrary waveform data. The data in either memory, or a portion of it, can be output like a standard waveform, or used to sweep a standard waveform.

The AFG 5101/5501 can generate a sweep that has a linear or logarithmic pattern; or data stored in an arbitrary waveform memory can be used to sweep a standard waveform output.

A dynamic marker can be displayed on any oscilloscope with x-y mode and can be shifted over the response plot. Up to 99 front panel set-ups can be stored in RAM for later recall. External signals can be used to modulate a standard waveform in frequency or amplitude.

Instrument Options

Option 02 adds a frequency lock synthesizer that provides an accurate output frequency by locking the output to an internal quartz crystal. This option operates in continuous mode only, from 12.1 Hz to 12 MHz.

Standard Accessories

The following items are shipped with the AFG 5101/5501:

- Instruction Manual
- Reference Guide
- Instrument Interfacing Guide

IEEE 488 (GPIB) Function Capability

The AFG 5101/5501 is capable of being remotely programmed via the digital interface specified in the IEEE Standard 488-1978, "Standard Digital Interface for Programmable Instrumentation." In this manual, the interface is called the General Purpose Interface Bus (GPIB).

The IEEE Standard identifies the interface function repertoire of an instrument on the GPIB in terms of interface function subsets. The subsets that apply to the AFG 5101/5501 are listed in Table 1-1.

NOTE

Refer to IEEE Standard 488-1978 for more detailed information. The standard is published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, New York 10017.

Table 1-1
INTERFACE FUNCTION SUBSETS

Function	Subset	Capability
Source Handshake	SH1	Complete capability.
Acceptor Handshake	AH1	Complete capability.
Basic Talker	T6	Responds to Serial Poll, Untalk if My Listen Address (MLA) is received.
Extended Talker (Secondary address)	TE0	No capability.
Basic Listener	L4	Unlisten if My Talk Address (MTA) is received.
Extended Listener (Secondary address)	LE0	No capability.
Service Request	SR1	Complete capability.
Remote-Local	RL1	Complete capability, including Local Lock-out.
Parallel Poll	PP0	Does not respond to Parallel Poll.
Device Clear	DC1	Complete capability.
Device Trigger	DT1	Complete capability.
Controller	C0	No controller function.
Electrical Interface	E2	Three-state driver capability.

ELECTRICAL CHARACTERISTICS

Performance Conditions

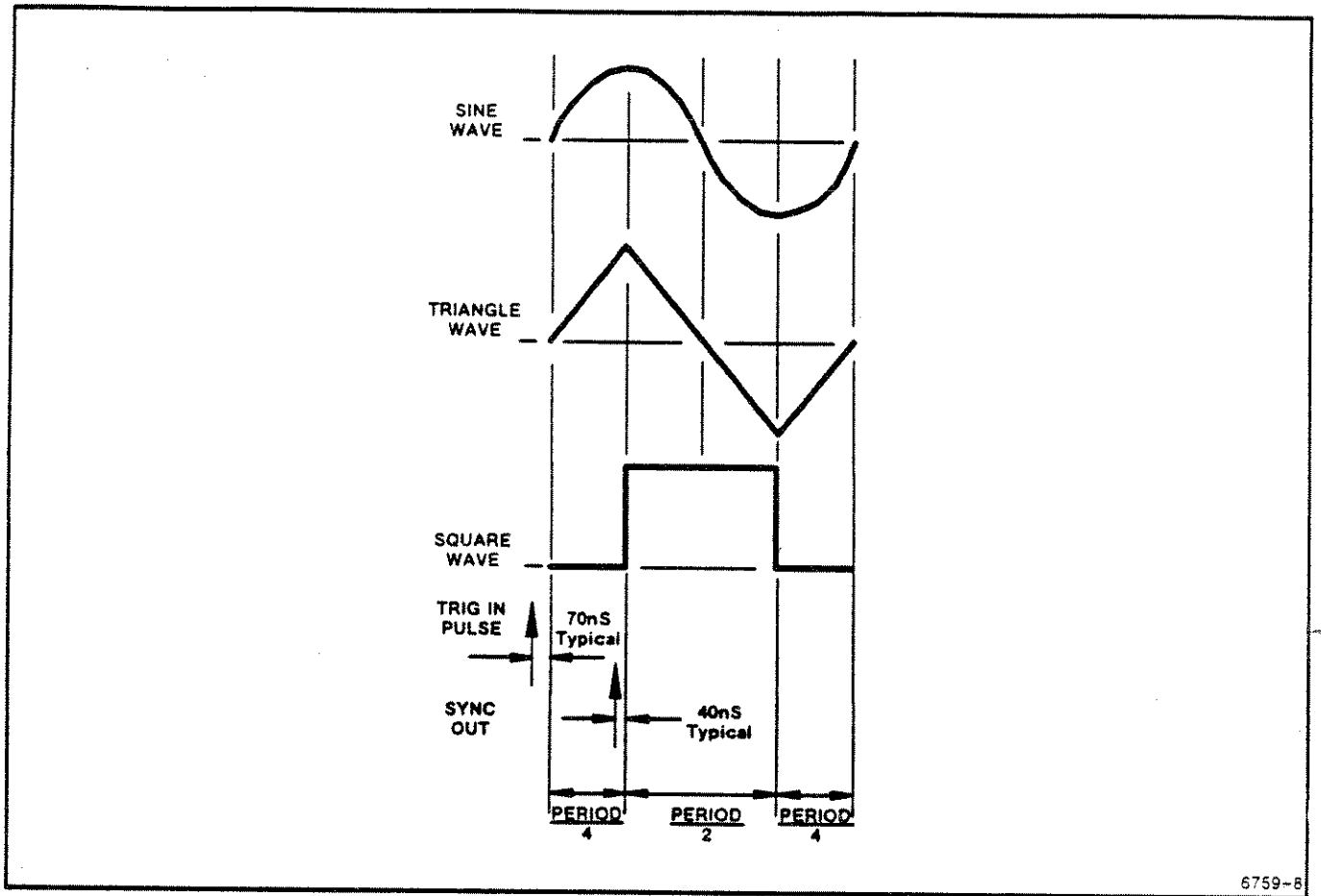
The electrical characteristics are valid under the following conditions:

1. The instrument must have been calibrated at an ambient temperature between +20°C and +30°C.
2. The instrument must be in a non-condensing environment whose limits are described under Environmental.
3. Allow thirty minutes warm-up time for operation to specified accuracy; sixty minutes after exposure to or storage in high humidity (condensing) environment.
4. The main OUTPUT connector must be terminated into a 50 ohm load.
5. There are no connections to the instrument other than those required to verify each specification.

Items listed in the Performance Requirements column of the following tables are verified by completing the Performance Check in the Service manual. Items listed in the Supplemental Information column may not be verified in the manual; they are either explanatory notes or performance characteristics for which no limits are specified.

Table 1-2
WAVEFORMS, OPERATING MODES, AND PARAMETERS

Characteristics	Performance Requirements	Supplemental Information
WAVEFORMS		
Standard Analog Functions: Sine, square, triangle, and dc:		Each waveform is one cycle, 1000 points in length; peak amplitude data values are fixed at + and -2047. Waveforms can be written to one of two arbitrary waveform memory banks at a user-selected address; a stored waveform (or a waveform part) can be executed from the arbitrary waveform execution buffer, and the output waveform attenuated by the instrument amplitude setting.
Arbitrary Waveform Functions: Predefined: Sine, square, triangle, ramp up, and ramp down:		
User-defined:		User can write data values (+ to -2047) to two arbitrary waveform memory banks at user-selected addresses; stored data value sequences can be executed from the arbitrary waveform execution buffer, and the output waveform attenuated by the instrument amplitude setting.
OPERATING MODES		
Continuous:	Output continuous at programmed frequency, amplitude, and offset.	
Triggered:	Output quiescent until triggered by an internal, external, GPIB, or manual trigger; then generates one cycle at programmed frequency, amplitude, and offset. See Fig. 1-1.	
Gated:	Same as triggered mode except waveform is executed for the duration of the gated signal. The last cycle started is completed.	



6759-8

Fig. 1-1. Trigger to waveform timing, and waveform phase relationships.

Table 1-2 (Cont)

Characteristics	Performance Requirements	Supplemental Information
Burst:	Same as triggered mode for programmed number of cycles from 1 to 9999, as set by the N BURST function.	
Sweep:	Internal, programmable start frequency, stop frequency, rate (time per step) and marker frequency. Linear, logarithmic, and arbitrary sweep shapes can be continuous, triggered, gated, or burst selected.	

Table 1-2 (Cont)

Characteristics	Performance Requirements	Supplemental Information
AM Modulation:	Generator can be externally modulated.	For 100% modulation, the AM IN signal amplitude is typically 4.5 Vp-p. AM % modulation $\geq 30\%$ from 10 Vp-p to 8 Vp-p output amplitude setting. AM % modulation to 100% is over limited output amplitude ranges. See table under 3.2.9, <i>Inputs and Outputs</i> , AM INPUT.
FM Modulation:	5V p-p for a minimum 500 : 1 frequency change.	Input resistance: 10k-ohm nominal. Slew rate: 0.1V per microsecond. Bandwidth: dc to 20 kHz.
Synthesizer:		An optional mode. See 3.2.8, Synthesizer.
OPERATING PARAMETERS		
Increment:	Frequency, amplitude, offset, rate, and Nburst can be manually incremented/decremented by a settable INCREMENT delta. Step rate is approximately 2 steps per sec. for the first 5 steps; then 10 steps per sec. for successive steps at one continuous keystroke.	The minimum INCREMENT delta is automatically set to the least significant digit of the current range (if the range changes, delta also changes). If INCREMENT delta is set via the front panel, it is locked to the new value until it is again set to 0 via the front panel. If INCREMENT delta is locked to an increment smaller than the LSD of the range, an error is displayed in the front panel.

Table 1-3
 FREQUENCY CHARACTERISTICS (STANDARD ANALOG FUNCTIONS)

Characteristics	Performance Requirements	Supplemental Information
RANGE:	0.012 Hz to 12.0 MHz.	
RESOLUTION:	3-1/2 digits (1200 counts).	Synthesizer mode (Option 02): 12000 counts (4.5 digits).
ACCURACY:	<p>$\pm 0.2\%$ of reading from 121 Hz to 5 MHz in continuous mode.</p> <p>0.5% of reading from 5 MHz to 12 MHz in continuous mode.</p> <p>5% of reading from 0.1 Hz to 120 Hz in continuous mode.</p>	<p>With frequency lock off, accuracy is $\pm 10\%$ from 0.1 Hz to 12 MHz.</p> <p>0.01% accuracy can be obtained from 0.001 Hz using predefined waveform functions in arbitrary mode.</p> <p>The synthesizer option offers 50 ppm accuracy from 12.1 Hz to 12 MHz.</p>
JITTER:		<0.1% to 5 MHz.
STABILITY:		<p>$\pm 0.2\%$ in continuous mode for all time intervals.</p> <p>0.5% for 24 hours in other modes.</p>
REPEATABILITY:		$\pm 1\%$ for 24 hours in other than continuous mode. In continuous locked mode, repeatability is equal to frequency accuracy listed above.
FREQUENCY LOCK MODE:		Power-on/default setting is Frequency Lock On. Refer to <i>Special Functions</i> in Section 2.
SETTLING TIME:		Typically less than 2 s.

Table 1-4
GENERAL OUTPUT CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information															
OFFSET	Absolute peak amplitude plus offset is limited to a maximum that is dependent on the signal amplitude range. Open circuit values are 2 times the displayed values. See table below.																
Range:	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th align="center" colspan="3">Offset Range and Resolution</th> </tr> <tr> <th align="center">Amplitude Range Amplitude + Absolute Offset into 50 ohms*</th> <th align="center">Peak into 50 ohms</th> <th align="center">Resolution</th> </tr> </thead> <tbody> <tr> <td align="center">1V - 9.99V</td> <td align="center">4.99V</td> <td align="center">10mV</td> </tr> <tr> <td align="center">0.1V - 0.999V</td> <td align="center">0.499V</td> <td align="center">1mV</td> </tr> <tr> <td align="center">0.01V - 0.099V</td> <td align="center">0.049V</td> <td align="center">1mV</td> </tr> </tbody> </table>		Offset Range and Resolution			Amplitude Range Amplitude + Absolute Offset into 50 ohms*	Peak into 50 ohms	Resolution	1V - 9.99V	4.99V	10mV	0.1V - 0.999V	0.499V	1mV	0.01V - 0.099V	0.049V	1mV
Offset Range and Resolution																	
Amplitude Range Amplitude + Absolute Offset into 50 ohms*	Peak into 50 ohms	Resolution															
1V - 9.99V	4.99V	10mV															
0.1V - 0.999V	0.499V	1mV															
0.01V - 0.099V	0.049V	1mV															
Resolution:	3 digits. See table above.																
Accuracy:	$\pm 0.6\%$ ± 20 mV into 50 ohms.																
Repeatability:	$\pm 1\%$ ± 20 mV for 24 hours.																
OUTPUT																	
Resistance:	50 ohms.																
Protection:	The instrument is nondestructively protected against short circuits or accidental voltage of up to 100 V (dc plus peak ac) applied to the main output connector.																
LOW SIGNAL AMPLITUDE NOISE:	Total noise and ripple less than 3 mV p-p with 10 mV output amplitude signal.																

Table 1-5
OUTPUT CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information								
SINE WAVE										
AMPLITUDE										
Range:	10 mV to 9.99 V p-p into 50 ohms.	20 mV to 19.98 V p-p from 50 ohms into open circuit. Open circuit values are 2 times the displayed values.								
Resolution:	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Amplitude Range</th> <th>Amplitude Resolution p-p into 50 ohms</th> </tr> </thead> <tbody> <tr> <td>1V - 9.99V</td> <td>10mV</td> </tr> <tr> <td>0.1V - 0.999V</td> <td>1mV</td> </tr> <tr> <td>10mV - 99mV</td> <td>1mV</td> </tr> </tbody> </table>	Amplitude Range	Amplitude Resolution p-p into 50 ohms	1V - 9.99V	10mV	0.1V - 0.999V	1mV	10mV - 99mV	1mV	
Amplitude Range	Amplitude Resolution p-p into 50 ohms									
1V - 9.99V	10mV									
0.1V - 0.999V	1mV									
10mV - 99mV	1mV									
Accuracy:	<p>$\pm 2.0\%$ ± 20 mV of programmed value for 1.0 to 9.99 V output at 20 to 30°C.</p> <p>$\pm 2.5\%$ ± 20 mV of programmed value for 1.0 to 9.99 V output; 3% ± 5 mV for 10 mV to 999 mV output, specified for a sinewave output at 1 kHz over full amplitude and temperature range.</p>									
Sine Distortion:	<p><0.6% THD (RMS), 121 Hz to 120 kHz at 5V p-p amplitude at 20 to 30°C.</p> <p><1% THD (RMS), 12 Hz to 120 kHz over full temperature and amplitude range.</p>	<p>All harmonics less than -30 dB below fundamental from 121 kHz to 1.0 MHz at 5V p-p amplitude and 20 to 30°C.</p> <p>All harmonics -20 dB below fundamental from 121 kHz to 12 MHz over full amplitude and temperature range.</p>								
Repeatability:		$\pm 1\%$ for 24 hours.								
Flatness:	0.5 dB from 0.012 Hz to 120 kHz, ± 2 dB to 1.2 MHz, ± 3 dB to 12 MHz referenced to 1 kHz sinewave.									

Table 1-5 (Cont)

Characteristics	Performance Requirements	Supplemental Information								
SQUARE WAVE										
AMPLITUDE										
Range:	10 mV to 9.99 V p-p into 50 ohms.	20 mV to 19.98 V p-p from 50 ohms into open circuit. Open circuit values are 2 times the displayed values.								
Resolution:	<table border="1"> <thead> <tr> <th>Amplitude Range</th> <th>Amplitude Resolution p-p 50 ohms</th> </tr> </thead> <tbody> <tr> <td>1V-9.99V</td> <td>10mV</td> </tr> <tr> <td>0.1V-0.999V</td> <td>1mV</td> </tr> <tr> <td>10mV-99mV</td> <td>1mV</td> </tr> </tbody> </table>	Amplitude Range	Amplitude Resolution p-p 50 ohms	1V-9.99V	10mV	0.1V-0.999V	1mV	10mV-99mV	1mV	
Amplitude Range	Amplitude Resolution p-p 50 ohms									
1V-9.99V	10mV									
0.1V-0.999V	1mV									
10mV-99mV	1mV									
Accuracy:	<p>$\pm 2.0\%$ ± 20 mV of programmed value for 1.0 to 9.99 V output at 20 to 30°C.</p> <p>$\pm 2.5\%$ ± 20 mV of programmed value for 1.0 to 9.99 V output; $\pm 3\%$ ± 5 mV for 10 mV to 9.99 mV output, specified for a squarewave output at 1 kHz.</p>									
Repeatability:		$\pm 1\%$ for 24 hours.								
Flatness:	0.5 dB from 0.012 Hz to 120 kHz, ± 2 dB to 1.2 MHz, ± 3 dB to 12 MHz referenced to 1 kHz squarewave.									
Time Symmetry:	<p>$< 0.5\%$, 121 Hz to 120 Hz,</p> <p>$\pm 1\%$, 121 Hz to 1.2 MHz;</p> <p>$\pm 5\%$, 1.2 MHz to 12 MHz.</p>									
Transition Time:	< 15 ns 10% to 90% at full output amplitude; elsewhere, < 20 ns, 10% to 90%.									
Aberrations:	<p>$< 8\%$ of p-p amplitude ± 20 mV from 3.4V to 9.99 Vp-p output amplitude.</p> <p>$< 10\%$ of p-p amplitude below 3.34 Vp-p output amplitude.</p>									

Table 1-5 (Cont)

Characteristics	Performance Requirements	Supplemental Information								
TRIANGLE WAVE										
AMPLITUDE Range:	10 mV to 9.99 V p-p into 50 ohms.	20 mV to 19.98 V p-p from 50 ohms into open circuit. Open circuit values are 2 times the displayed values.								
Resolution:	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Amplitude Range</th> <th>Amplitude Resolution p-p 50 ohms</th> </tr> </thead> <tbody> <tr> <td>1V-9.99V</td> <td>10mV</td> </tr> <tr> <td>0.1V-0.999V</td> <td>1mV</td> </tr> <tr> <td>10mV-99mV</td> <td>1mV</td> </tr> </tbody> </table>	Amplitude Range	Amplitude Resolution p-p 50 ohms	1V-9.99V	10mV	0.1V-0.999V	1mV	10mV-99mV	1mV	
Amplitude Range	Amplitude Resolution p-p 50 ohms									
1V-9.99V	10mV									
0.1V-0.999V	1mV									
10mV-99mV	1mV									
Accuracy:	<p>$\pm 2.0\%$ ± 20 mV of programmed value for 1.0 to 9.99 V output at 20 to 30°C.</p> <p>$\pm 2.5\%$ ± 20 mV of programmed value for 1.0 to 9.99 V output; $\pm 3\%$ ± 5 mV for 10 mV to 9.99 mV output, specified for a triangle wave output at 1 kHz.</p>									
Triangle Linearity:		98% to 100 kHz measured from 10% to 90% on waveform.								
Repeatability:		$\pm 1\%$ for 24 hours.								
Flatness:	0.5 dB from 0.012 Hz to 120 kHz, ± 2 dB to 1.2 MHz, ± 3 dB to 12 MHz referenced to 1 kHz triangle wave.									

Table 1-5 (Cont)

Characteristics	Performance Requirements	Supplemental Information								
DC										
AMPLITUDE Range:	± 10 mV to ± 4.99 Vdc into 50 ohms.	± 20 mV to ± 9.98 Vdc from 50 ohms into open circuit. Open circuit values are 2 times the displayed values.								
Resolution:	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Amplitude Range</th> <th>Amplitude Resolution p-p 50 ohms</th> </tr> </thead> <tbody> <tr> <td>1V-9.99V</td> <td>10mV</td> </tr> <tr> <td>0.1V-0.999V</td> <td>1mV</td> </tr> <tr> <td>10mV-99mV</td> <td>1mV</td> </tr> </tbody> </table>	Amplitude Range	Amplitude Resolution p-p 50 ohms	1V-9.99V	10mV	0.1V-0.999V	1mV	10mV-99mV	1mV	
Amplitude Range	Amplitude Resolution p-p 50 ohms									
1V-9.99V	10mV									
0.1V-0.999V	1mV									
10mV-99mV	1mV									
Accuracy:	$\pm 0.6\%$ ± 20 mV into 50 ohms.									
Repeatability:		$\pm 1\%$ for 24 hours.								

Table 1-6
INTERNAL TRIGGER

Characteristics	Performance Requirements	Supplemental Information
RANGE:	Repetition rate 100 ns to 999.9 s.	
RESOLUTION:	4 digits.	1 ns maximum resolution.
ACCURACY:	0.01%.	

**Table 1-7
ARBITRARY WAVEFORM CHARACTERISTICS**

Characteristics	Performance Requirements	Supplemental Information												
FUNCTIONS:	User-defined, or resident sine, square, triangle, ramp up, and ramp down.	0.01% frequency accuracy from 0.001 MHz to 10 kHz using resident waveform functions.												
HORIZONTAL RESOLUTION:	8192 points for each waveform storage memory. Resident functions are defined with 1000 points of horizontal resolution.	See Point Duration, below, for horizontal timing range.												
VERTICAL RESOLUTION:	12 bits, 4095 points.													
<p>SUPPLEMENTAL INFORMATION: At the maximum amplitude setting of 9.99V, resolution is 2.44 mV per vertical point.</p> <p>ASCII: $\frac{\text{Data point entered}}{2047} \times \frac{\text{Amplitude setting}}{2} + \text{Offset} = \text{Output voltage for data point}$ </p> <p>Binary Block: $\frac{\text{Data point} - 2047}{2047} \times \frac{\text{Amplitude setting}}{2} + \text{Offset} = \text{Output voltage for data point}$ </p>														
OUTPUT ACCURACY	±2.5% ±20 mV of programmed p-p amplitude when arbitrary data point peak values are +2047 to -2047 at waveform frequencies of 1 kHz with predefined waveform functions.													
ARBITRARY MODE BANDWIDTH:	3dB point typically ≥3 MHz. Measured with a 2 point waveform from -2047 to +2047 at 9.99 V amplitude.													
VERTICAL RANGE:	<table border="1"> <thead> <tr> <th></th> <th align="center">Most Neg. Voltage</th> <th align="center">Most Pos. Voltage</th> </tr> </thead> <tbody> <tr> <td>Front panel (ASCII):</td> <td align="center">-2047</td> <td align="center">2047</td> </tr> <tr> <td>GPIB (ASCII):</td> <td align="center">-2047</td> <td align="center">2047</td> </tr> <tr> <td>GPIB (Binary Blk):</td> <td align="center">0</td> <td align="center">4095</td> </tr> </tbody> </table>			Most Neg. Voltage	Most Pos. Voltage	Front panel (ASCII):	-2047	2047	GPIB (ASCII):	-2047	2047	GPIB (Binary Blk):	0	4095
	Most Neg. Voltage	Most Pos. Voltage												
Front panel (ASCII):	-2047	2047												
GPIB (ASCII):	-2047	2047												
GPIB (Binary Blk):	0	4095												
POINT DURATION (RATE):	100 ns to 999.9 s with 4 digits resolution.	Accuracy better than 0.01%.												
RISE TIME:	<150 ns 10% to 90% (with no filtering).													

Table 1-7 (Cont)

Characteristics	Performance Requirements	Supplemental Information
SETTLING TIME:	<300 ns to within 1% of final value with a full scale step (with no filtering).	
WAVEFORM STORAGE MEMORIES:	Two independently selectable memory banks of 8192 points each.	Non-volatile.
WAVEFORM EXECUTION START AND STOP POINTS:	Waveform execution START and STOP points may be defined at any address within either of the two 8192-point waveform storage memories. The STOP point must be higher than the START point.	
WAVEFORM EXECUTION BUFFER:	8192 points.	The arbitrary waveform is generated from the data values at sequential addresses between the previously defined START and STOP points in the selected waveform storage bank.
FILTERS:(4 filters, single-pole):		3 dB cutoff frequency.
0		Filter off.
1		Typically 1 MHz \pm 20%.
2		Typically 100 kHz \pm 20%.
3		Typically 11 kHz \pm 20%.
4		Typically 1.3 kHz \pm 20%.
SINE DISTORTION (Pre-defined arbitrary waveforms):		Typically 1.5% sine distortion at 1 kHz output frequency. Can be improved by use of filters.





Table 1-8
FREQUENCY SWEEP

Characteristics	Performance Requirements	Supplemental Information
SWEEP TYPES:		Linear, logarithmic, arbitrary.
SWEEP TIME:	100 ns to 999.9 s per point. 1 ns (4 digit) maximum resolution. (Linear and logarithmic sweep only: 1 sweep equals 1000 points for the time base.)	User-defined arbitrary sweeps may be defined with up to 8192 horizontal points (time base).
SWEEP WIDTH:	1200 : 1 maximum; start frequency and stop frequency must be in the same range. See sweep ranges specification.	If the highest frequency is less than the top of the range, the ratio is less than 1200 : 1.
SWEEP RANGES:	10 kHz to 12 MHz 1 kHz to 1.2 MHz 100 Hz to 120 kHz 10 Hz to 12 kHz 1 Hz to 1.2 kHz 0.1 Hz to 120 Hz 0.012 Hz to 12 Hz	The highest frequency of the two (START and STOP) determines the sweep range.
ACCURACY OF START/STOP FREQUENCIES:		$\pm 5\%$ of highest frequency of range, typical.
MARKER ACCURACY:		$\pm 5\%$ typical.

Table 1-9
SYNTHESIZER (OPTION 02)

Characteristics	Performance Requirements	Supplemental Information
RANGE:	12.1 Hz to 12 MHz.	
RESOLUTION:	Frequency resolution (LSD of display) is 10 mHz on lowest range and 1 kHz on highest frequency range (4.5 digits, or 12000 counts).	
ACCURACY:	± 50 ppm averaged measurement.	
STABILITY:	± 10 ppm/degree C or better.	
SETTLING TIME:		Typically less than 2 s plus 100 cycles.

Table 1-10
INPUTS AND OUTPUTS

Characteristics	Performance Requirements	Supplemental Information
VCO/FM INPUT: 	5 V p-p for a 500:1 minimum frequency change.	Input resistance: 10k ohm nominal. Slew rate: 0.1 V per microsecond. Bandwidth: dc to 20 kHz. FM operation may require DC biasing of the modulation signal ± 5 Vdc.
TRIGGER IN: 	TTL compatible.	Nominal impedance: 10k ohms. Maximum rate: 12 MHz. Minimum width: 20 ns.
AM INPUT: 		Input resistance: 10k ohm nominal. Bandwidth: dc to 20 kHz minimum. 5 V p-p for 100% modulation, typical, within allowable amplitude ranges. AM % modulation $\geq 30\%$ from 10 Vp-p to 8 Vp-p output amplitude setting. AM % modulation to 100% over limited output amplitude ranges: 10 mV to 23 mV p-p 34 mV to 45 mV p-p 100 mV to 230 mV p-p 334 mV to 450 mV p-p 1.00 V to 2.3 V p-p 3.34 V to 4.5 V p-p.
ARBITRARY HOLD INPUT: 	TTL compatible.	When this signal is high, the arbitrary output stops and the output voltage remains at the level of the last point output. When the signal is brought low, the output of the arbitrary waveform continues. Refer to Fig. 1-2.
INPUT PROTECTION:	All inputs protected against up to ± 50 V (dc plus peak ac) accidental input.	
SYNC OUTPUT:	TTL level squarewave at programmed frequency.	Resistance from 50 ohms, protected against short circuit and up to ± 15 V accidental input (for less than 1 minute).
SWEEP OUTPUT:	Source resistance is 600 ohms; same wave shape as selected sweep. Amplitude is dependent on start and stop frequency and a 5V limit.	In the arbitrary sweep mode, this output reflects the amplitude of the arbitrary waveform that drives the sweep waveform.

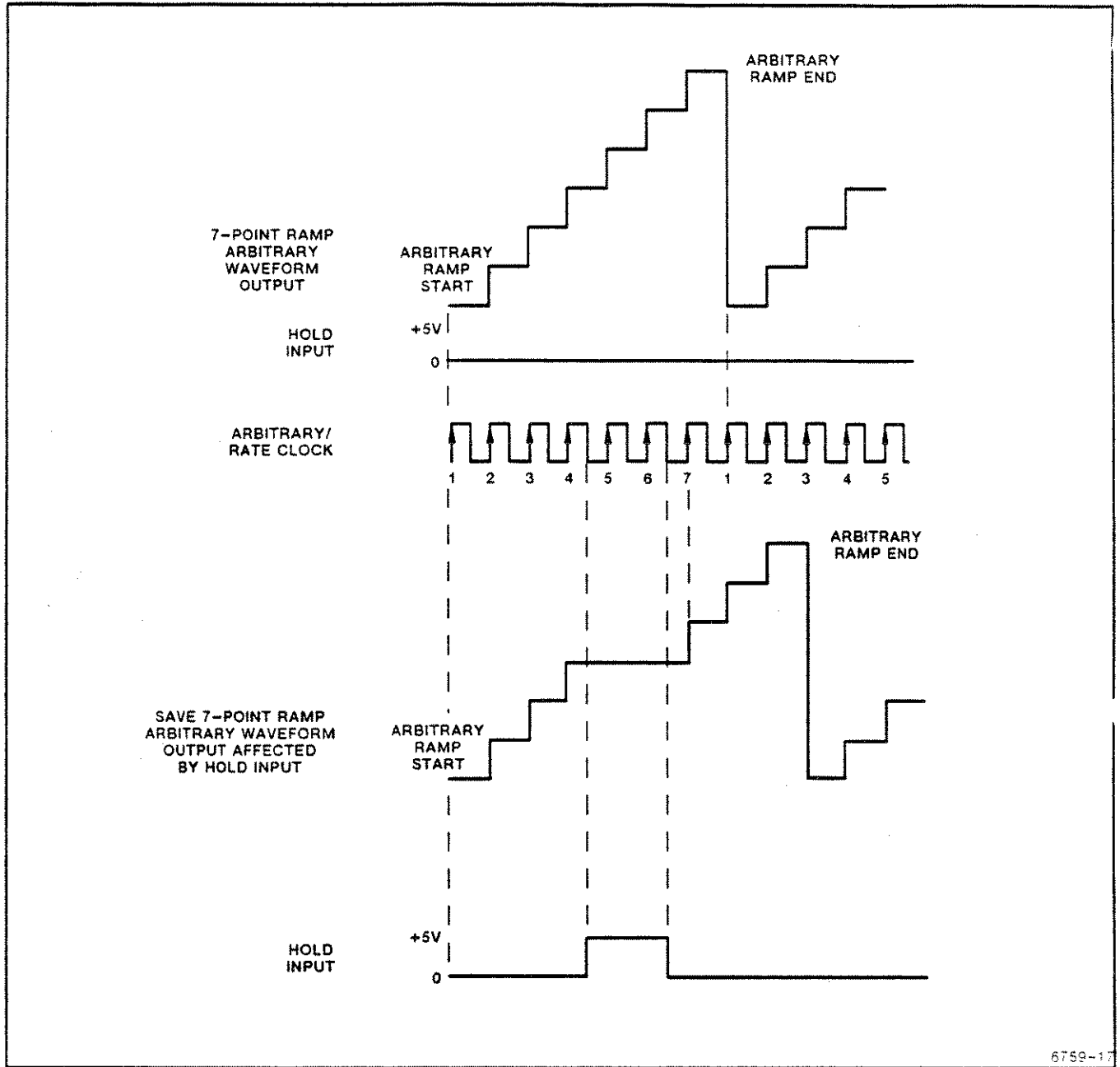


Fig. 1-2. Arbitrary HOLD timing diagram.

Table 1-10 (Cont)

Characteristics	Performance Requirements	Supplemental Information
MARKER OUT:	Positive TTL level pulse, output when the output frequency equals the marker frequency. Pulse duration is equal to a minimum of one period of the RATE setting.	

Table 1-11
GPIB CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
INTERFACE:	Conforms to IEEE-488 1978. See section 4.2 for information on the supported subsets.	

**Table 1-12
MISCELLANEOUS ELECTRICAL CHARACTERISTICS**

Characteristics	Performance Requirements	Supplemental Information
Internal Fuse Data:		1 fuse: 2A, 125V slow blow. (U.L. listed component.) 2 fuses: 1 A, 125 V slow blow. (U.L. listed component.)
Power Consumption: (AFG 5101)	50 VA maximum, limited by internal fuse.	
Power Dissipation: (AFG 5101)	30 W.	
Recommended Adjustment Interval:	1000 hours or 6 months, whichever occurs first.	
Warm-up Time:	30 minutes.	
Memory Backup Battery Life:		5 years, typical.

**Table 1-13
SOURCE POWER REQUIREMENTS
AFG 5501 Only**

Characteristics	Performance Requirements	Supplemental Information
Voltage Ranges:		Selectable 100 V, 120 V, 220 V, and 240 V nominal line $\pm 10\%$.
Line Frequency:		50 - 60 Hz.
Maximum Power Consumption:		Approximately 90 W.
Fuse Data:		
100 V, 120 V Ranges:		1.0 A, 3 AG, slow blow, 250 V.
220 V, 240 V Ranges:		0.5 A, 3 AG, slow blow, 250 V.

ENVIRONMENTAL CHARACTERISTICS

Table 1-14
ENVIRONMENTAL^a

Characteristics	Description	
TEMPERATURE		Meets MIL-T-28800D, class 5.
Operating:	0°C to +50°C	
Non-Operating:	-20°C to +60°C	Class 5 non-operating temperature exception due to internal keep-alive battery and LCD display.
HUMIDITY:	95% RH, 0°C to 30°C 75% RH to 40°C 45% RH to 50°C	Exceeds MIL-T-28800D, class 5, non-condensing.
ALTITUDE:		Exceeds MIL-T-28800D, class 5.
Operating:	4.6 km (15,000 ft.)	
Non-Operating:	15 km (50,000 ft.)	
VIBRATION ^c	0.38 mm (0.015") peak-to-peak, 5 Hz to 55 Hz, 75 minutes.	Meets MIL-T-28800D, class 5, when installed in qualified power modules. ^b
SHOCK ^c	30 g's (1/2 sine) 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks.	Meets MIL-T-28800D, class 5 when installed in qualified power modules. ^b
BENCH HANDLING ^d	12 drops from 45°, 4" or equilibrium, whichever occurs first.	Meets MIL-T-28800D, class 5, when installed in qualified power modules. ^b
TRANSPORTATION ^d	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.	
EMC ^e	Within limits of F.C.C Regulations Part 15, Subpart J, Class A; and MIL-461B (1980) for RE01, RE02, CE01, CE03, RS01, RS03, CS01, CS02, and CS06.	
ELECTRICAL DISCHARGE		
Operating Maximum Test Voltage:	15 kV, 150 pF through 150 ohms.	
Non-Operating Max. Test Voltage:	20 kV, 150 pF through 150 ohms.	

^aWith power module.^bRefer to TM 500/5000 power module specifications.^cRequires retainer clip.^dWithout power module.^eSystem performance subject to exceptions of power module and/or other plug-ins.

Table 1-14 (Cont)

Characteristics	Description
SAFETY SPECIFICATIONS:	Shall meet the following safety standards:
U.S.A.:	UL1244 (Electrical and Electronic measuring and test equipment).
Canada:	CSA 556B (Electrical Bulletin).
International:	IEC 348 (Electronic measuring apparatus).

PHYSICAL CHARACTERISTICS

Table 1-15
MECHANICAL

Characteristics	Description
FINISH:	
Front Panel:	Polycarbonate.
Chassis: (AFG 5101)	Chromate conversion-coated aluminum.
NET WEIGHT	
AFG 5101:	1.7 kg (4.6 lbs)
AFG 5501:	5.3 kg (14.3 lbs)
OVERALL DIMENSIONS	
<u>AFG 5101</u>	
Height:	12.7 cm (5.0 in)
Width:	20.32 cm (8.0 in)
Length:	27.94 cm (11.0 in)
<u>AFG 5501</u>	
Height:	14.0 cm (5.5 in)
Width:	23.4 cm (9.2 in)
Length:	43.2 cm (17.0 in)
ENCLOSURE TYPE & STYLE PER MIL-T-28800D (AFG 5101 in Tektronix TM 5000 Series power module):	
Type	III
Style:	E (Style F with rackmount kit)

OPERATING INSTRUCTIONS

Introduction

This section of the manual provides installation and removal instructions and describes the functions of the AFG 5101/5501 front-panel controls and connectors. This information is provided as an aid in understanding how to operate the AFG 5101/5501 under local (manual) control only. The information in this section assumes the instrument is not connected to the GPIB. Complete information for programming the AFG 5101/5501 via the GPIB (General Purpose Interface Bus) is found in the Programming section of this manual.

Preparation for Use

Installation and Removal—AFG 5101 Only

NOTE

The AFG 5101 is designed to operate only in a TM 5000-Series power module. Refer to the power module instruction manual before installing the AFG 5101.

The AFG 5101 is calibrated and ready for use when received. It operates in three compartments of any TM 5000-Series GPIB compatible power module. Refer to the power module instruction manual for line voltage requirements and power module operation.

CAUTION

To prevent damage to the AFG 5101, turn the power module off before installation or removal. Do not use excessive force to install or remove.

Check to see that the plastic barriers on the interconnecting jacks of the selected power module compartments match the cutouts in the AFG 5101 circuit board edge connectors. If these do not match, do not insert the instrument until the reason is determined. When the units are properly matched, align the AFG 5101 chassis with the upper and lower guides of the selected compartments. Insert the AFG 5101 into the power module

and press firmly to seat the circuit board edge connectors in the power module interconnecting jacks. Apply power to the AFG 5101 by actuating the power switch on the power module.

To remove the AFG 5101 from the power module, pull both release latches on the front panel until the interconnecting jack disengages. The instrument will then slide straight out.

Power Cords—AFG 5501 Only

The AFG 5501 is shipped with the power cord option as ordered by the customer (see Fig. 2-1). Verify that the instrument power cord is the proper cord for use with the available power.







PLUG CONFIGURATION	USAGE	LINE VOLTAGE	REFERENCE STANDARDS	OPTION NUMBER
	North American 120/15A	120V	ANSI C73.11 NEMA 5-15-P IEC 83	
	Universal Euro 240V/ 10-16A	240V	CEE (7), II, IV, VII IEC 83	A1
	UK 240V/ 13A	240V	BS 1363 IEC 83	A2
	Australian 240V/ 10A	240V	AS C112	A3
	North American 240V/ 15A	240V	ANSI C73.20 NEMA 6-15-P IEC 83	A4
	Switzerland 220V/ 6A	220V	SEV	A5

Fig. 2-1. Power cords.

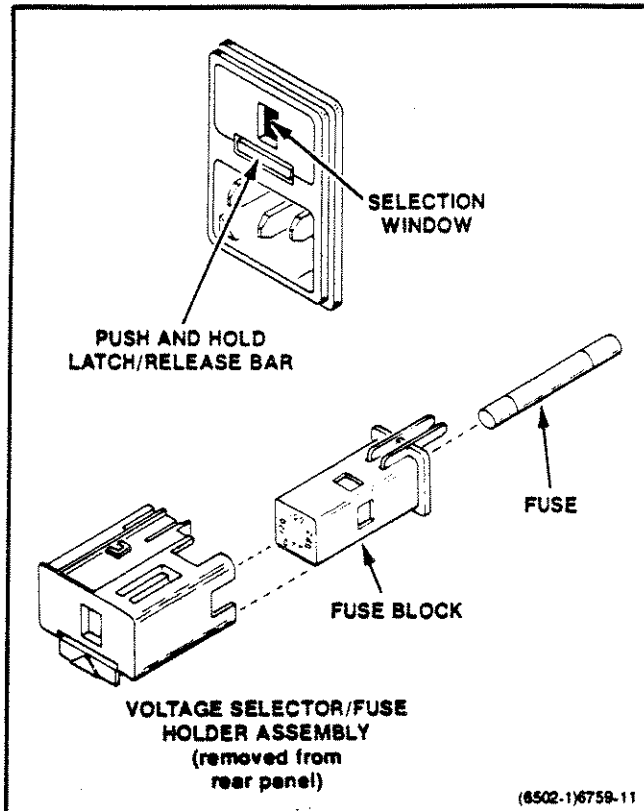


Fig. 2-2. Line voltage selection/fuse replacement.

Line Voltage Selection/Fuse Replacement—AFG 5501 Only

NOTE

The AFG 5501 contains fuses in the voltage selector/fuse holder assembly located on the rear panel. The instrument also contains internal fuses; refer qualified service personnel to the Maintenance section of this manual for information on internal fuse replacement.

The line voltage selector is part of the line cord plug assembly, located on the rear of the power module. Verify that the voltage shown in the selector window is correct for the line voltage available.

If the displayed voltage selection is incorrect or the fuse needs replacement, perform the following procedure. Refer to Fig. 2-2.

1. Make certain that the power switch (on rear of unit) is turned off and the line cord is not plugged into the line voltage connector.
2. Remove the voltage selector/fuse holder by pushing the latch/release bar toward the selection window. The selector/fuse holder should release and move slightly out of the socket. Remove the voltage selector/fuse holder from the assembly.
3. Pull the fuse block and fuse from the voltage selector/fuse holder. Remove the fuse from the fuse block. Make certain a replacement fuse has the proper ratings for the selected line voltage (refer to Specifications for fuse rating). Insert fuse into fuse block.
4. The line voltage selections are printed on the end of the fuse box. Rotate the fuse box and reinstall it so that the proper line voltage selection is visible through the selection window.
5. Reinstall the voltage selector/fuse holder.
6. Verify that the correct line voltage value is visible through the line voltage selector window.

Turn-On Procedure

After completing the appropriate Preparation For Use instructions, install the power cord and connect it to the proper power outlet. Turn on the power switch on the instrument rear panel.

IEEE 488 (GPIB) Connector—AFG 5501 Only

Figure 2-3 shows the pin assignments for the rear panel GPIB connector.

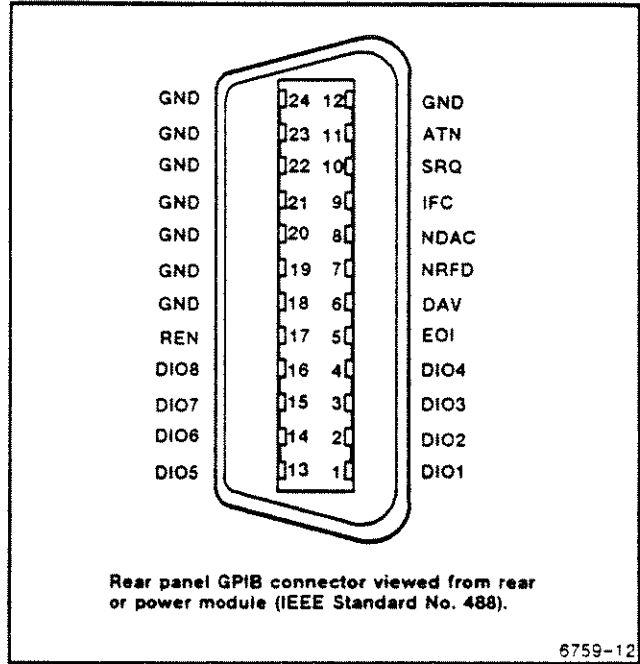


Fig. 2-3. Rear panel GPIB connector.

Repackaging For Shipment

If the instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted. Include complete instrument serial number and a description of the service required.

If the original package is unfit for reuse or unavailable, repackage the instrument as follows:

Wrap the instrument with polyethylene sheeting or other suitable material to protect the exterior finish. Obtain a carton of corrugated cardboard of adequate strength and having inside dimensions no less than six inches more than the dimensions of the instrument. Cushion the instrument by tightly packing dunnage or urethane foam between the carton and instrument, on all sides. Seal the carton with shipping tape or use an industrial stapler.

The carton test strength for your instrument is:

- AFG 5101: 200 pounds per square inch
- AFG 5501: 275 pounds per square inch

Controls, Connectors, and Display

General Information

All controls and connectors used for local (manual) operation of the AFG 5101/5501 are located on the front panel. The front panel keys are used to select a parameter, or function for the waveform output; to display the current value of the parameter, or function; and to change its value, if desired. Other keys select the trigger source and mode. The DATA keypad is used to enter a different value for the selected key function. Some keys have built-in LEDs that illuminate to indicate that the associated function is active. On all keys that include LEDs, the indicators light only while a parameter or function is selected, or is active.

Display Window, Changing Settings

The AFG 5101/5501 has a two-row LCD in the display window that can show up to 16 characters per row. When the AFG 5101/5501 is on, each row displays a function, parameter, etc., and its current setting. For example, the default display shows the current setting for frequency and amplitude. Depending on the key function, selection allows the user to

- * Display the current setting of a key function. For example, if frequency and amplitude are displayed, press N BURST to see its current setting.
- * Change the current setting of a key function. For example, press N BURST, press a DATA numeric key such as 6, press ENTER.
- * Turn on, or enable the selected key function, without changing its current setting. For example, if DC was previously set to 1 V, but is now off (LED off), turn on the DC function by pressing DC, ENTER.
- * Display the current setting of a key function, change that setting using the DATA keypad (numeric and units of measure keys), and turn on or enable the function, etc., with the new setting. For example, press SWEEP, DATA key 4, ENTER. The output at the SWEEP OUT connector is a logarithmic sweep.

(The other displayed characteristic or one that is not displayed can be selected by pressing its front panel key.)

A right caret in the left display area indicates which of the two displayed items is "selected", or "can be acted upon" using front panel keys. Refer to Fig. 2-4, part A.

An asterisk is displayed in place of the right caret when a DATA key is pressed (to change the displayed numeric setting). Refer to Fig. 2-4, part B. The DATA keys are used to change the displayed numeric setting; some DATA keys also can change the units of measure (units are function key dependent). The asterisk indicates that the settings change is incomplete and must be concluded by pressing the ENTER key. Refer to Fig. 2-4, part C.

A numeric settings change in process can be aborted by pressing any key other than DATA and INST ID keys; also a timeout of about 9 seconds will abort the incomplete change. When a settings change is completed, the asterisk reverts to a right caret.

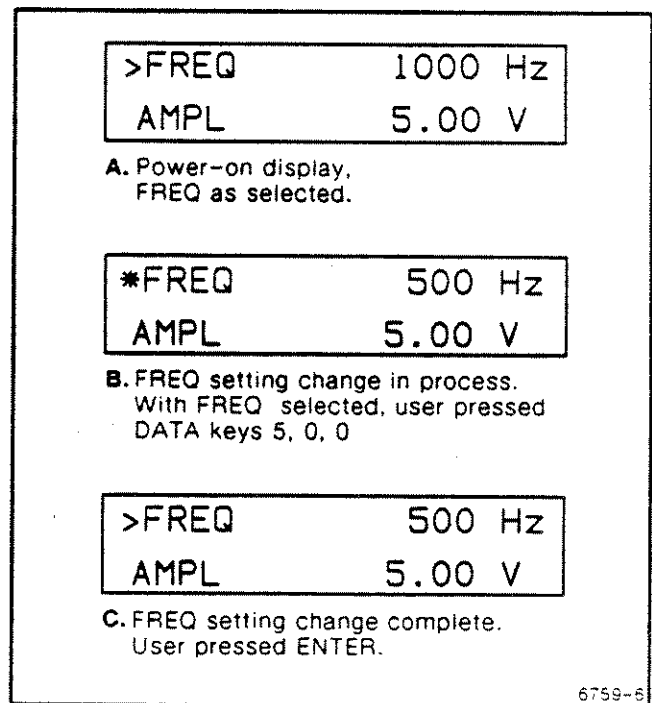


Fig. 2-4. Front panel numeric setting change.

Power-On Sequence

At power-on, the AFG 5101/5501 performs a self test to verify internal circuit operation. When a self test error, internal error, or operating error occurs, an error code and code mnemonics are displayed to give some explanation of the type of error. Error codes are listed and described in Table 2-2. If no error is found during self test, the instrument enters the local state with the settings listed in Table 2-1.

Table 2-1
POWER-ON SETTINGS

Key/Function	Setting
AMPL	5 V
Amplitude Modulation	off
Arbitrary ADRS	0000
Arbitrary ADRS Increment (SPCL 310)	on
Arbitrary Bank Select	1
Arbitrary Filter	0 (off)
Arbitrary PROG Mode	off
Arbitrary START	0000
Arbitrary STOP	8191
DC	0 V
Device Trigger ^a	off
FREQ	1 kHz
Frequency Lock (SPCL 230)	on
Frequency Modulation	off
Function	SINE
MODE	CONT
N BURST	2
OFFSET	0 V (off)
Operation Complete ^a	off
OUTPUT	off
RATE	10 microseconds
RATE units (SPCL 210)	time
Range Lock (SPCL 260)	off
Request Service (RQS) ^a	on
SWEEP	off
MARKER (SPCL 250)	off
MARKER Frequency	0 Hz (off)
Sweep START Frequency	1 Hz
Sweep STOP Frequency	1200 Hz
TRIG	MAN
User Service Request ^a	off

^aSettings used only when AFG 5101/5501 is under program control.

GPIB Indicators

The REMOTE and ADRS indicators illuminate only when the instrument is operating under remote program control via the GPIB.

REMOTE -- Illuminates when the AFG 5101/5501 is operating under remote program control via the GPIB.

ADRS -- Illuminates when the AFG 5101/5501 is either "listening" or "talking" over the GPIB.

Controls and Connectors

The following description explains the function of each front panel control and connector. The number associated with each description pinpoints the location of the key or connector on the front panel in Fig. 2-5.

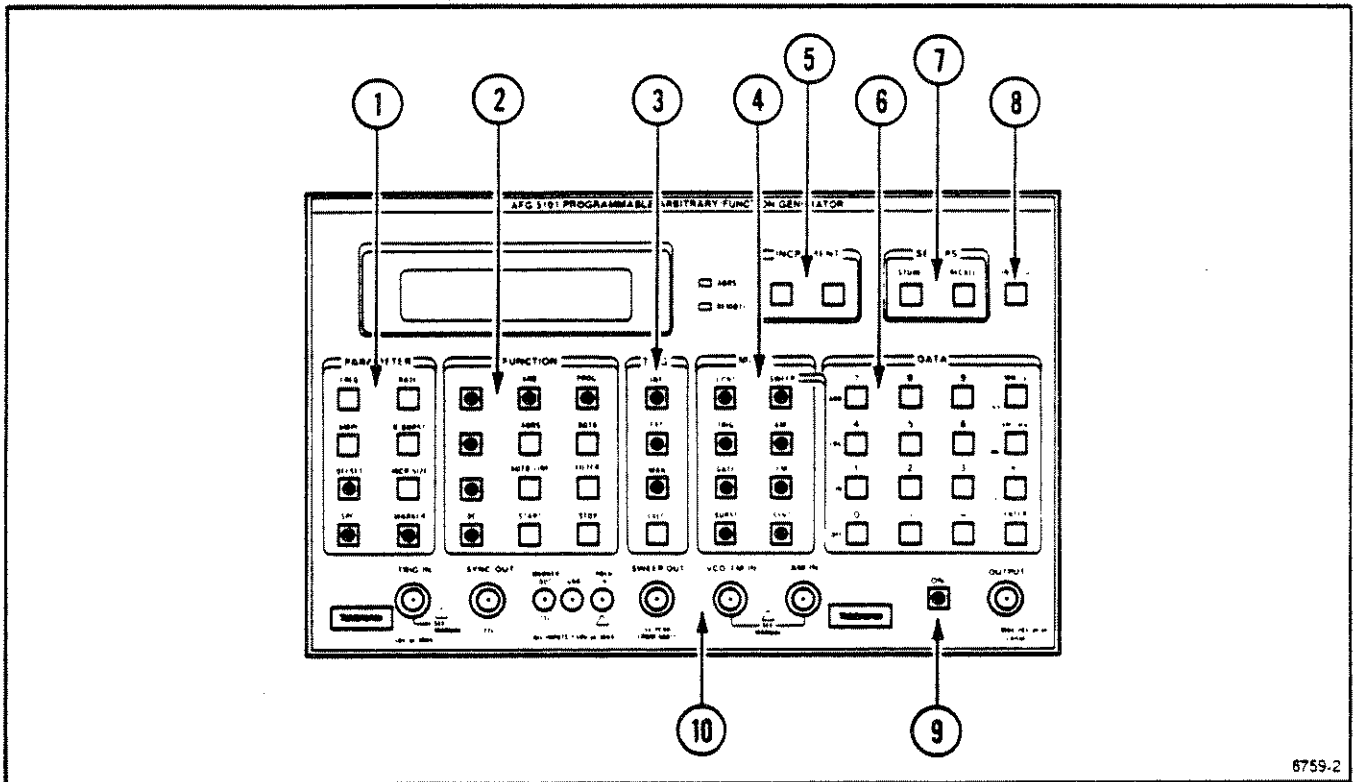


Fig. 2-5. Controls and connectors.

① PARAMETER Keys

The PARAMETER keys are used to select a parameter for the waveform selected for output from the AFG 5101/5501; to display the current value of the parameter; and to change its value and/or units of measure using the DATA keypad. The PARAMETER keys are mutually exclusive in operation.

- FREQ** Selects the FREQ parameter and displays the current frequency of the output function.
- AMPL** Selects the AMPL parameter and displays the current amplitude of the output function.
- OFFSET** Selects the OFFSET parameter and displays the current offset; the key LED lights if the offset voltage is a value other than zero (0); a zero value disables OFFSET.
- SPCL** Selects any of 11 special functions from a menu, using the sequence: SPCL key; press INCREMENT to page through menu (displayed, one function at a time) to the desired function; or enter the SPCL code (3 digits, using DATA keypad) and press ENTER. Refer to *Special Functions* in this section of the manual for more information. To exit a special function, press any FUNCTION key.
- RATE** Selects the RATE parameter and displays the current RATE setting. RATE is function/mode dependent; its setting controls the rate at which the AFG 5101/5501 scans through arbitrary memory, and/or controls the sweep rate and sets the marker width, and sets the internal trigger rate. Units of measure can be set to time or frequency using SPCL function 210.
- N BURST** Selects the N BURST parameter and displays the current number of cycles that will be generated in BURST mode.
- INCR SIZE** Selects the INCR SIZE parameter and displays the current step size used for incrementing and

decrementing the selected parameter (FREQ, AMPL, OFFSET, MARKER, N BURST, DC, and RATE). If INCR SIZE is set to 0 (the power-on default setting), then the increment size is the least significant digit of the selected parameter range (displayed). If INCR SIZE is set to a value less than the least significant digit, then an error is displayed (error code 14) and the parameter remains unchanged.

- MARKER** Selects the MARKER parameter and displays the current frequency of the sweep marker. MARKER pulse is equal to a minimum of one period of the RATE setting. The LED is on only if the marker frequency is other than zero. The MARKER is off when the frequency is 0. An error is generated if the MARKER frequency is out of the START and STOP frequency range. SPCL function 250 also affects the MARKER function.

② FUNCTION Keys

The FUNCTION keys are used to select the type of waveform to be supplied as output from the AFG 5101/5501. These keys are mutually exclusive in operation. Some keys operate in either of two modes. Also, START and STOP each have two settings—one that is set in the Non-Prog Mode and is used for standard sweep operations; another that is set in the arbitrary waveform Prog Mode and used to set the START and STOP addresses in arbitrary waveform memory.

- SINE** Selects a sine-wave output (LED on).
- TRIANGLE** Selects a triangle-wave output (LED on).
- SQUARE** Selects a square-wave output (LED on).
- DC** Selects a dc-voltage output (LED on) at the selected voltage. Press ENTER to initiate output.

- ARB** Selects arbitrary waveform output. The waveform selected depends on:
- * The waveform memory bank selected.
 - * The current START address.
 - * The current STOP address.
 - * The data stored at and between the START and STOP addresses.
 - * The RATE setting.

When the ARB key is pressed, the instrument copies the data that resides in the selected arbitrary waveform memory between the START and STOP addresses into the arbitrary waveform execution buffer and initiates execution.

- FILTER** Selects or deselects one of four fixed filters for application to an arbitrary waveform output. To select a new filter, press FILTER, and the filter number (DATA keypad numbers 1 through 4). Selecting 0 disables filtering.

Filter No.	Typical Cut-off Frequency
1	1 MHz
2	100 kHz
3	11 kHz
4	1.3 kHz

- START** (Non-PROG Mode) Selects the sweep START frequency.
- STOP** (Non-PROG Mode) Selects the sweep STOP frequency.

PROG MODE. The following FUNCTION keys are used in arbitrary waveform programming operations only.

- PROG** Selects (LED on) and deselects the arbitrary waveform programming mode and displays the current arbitrary waveform memory bank. With PROG on, arbitrary

waveform attributes can be modified; also, memory bank selection can be changed (a bank selection change sets the address pointer (ADRS) to 0 in new bank). To enter the PROG mode, press PROG; the current data bank is displayed; change the current bank selection, if desired; press ENTER.

Arbitrary waveform execution cannot be started while PROG is selected. However, with ARB PROG on (SPCL function 330) and while an arbitrary waveform is executing, the user can select PROG and modify arbitrary waveform memory data. The arbitrary waveform execution buffer is updated at the end of the current execution cycle.

The following keys function as described only while the arbitrary program mode is enabled (PROG LED on).

- ADRS** (PROG Mode) Used to display the current destination address in the currently selected arbitrary waveform memory bank for recording a DATA point. (Also displays the current data value stored at the selected address.) Current address is 0 in new arbitrary waveform memory bank when bank selection is changed.) To change the destination address, press ADRS, enter the address (using the DATA keypad), press ENTER. The address can automatically increment when a data point is entered (SPCL function 310, PROG mode). Address range: 0 to 8191.

- AUTOLINE** (PROG Mode) AUTOLINE automatically calculates data values that represent a straight line connecting the two last-entered arbitrary waveform memory bank addresses, and writes that data between those addresses. Pressing AUTOLINE displays the two last-entered addresses; then, pressing ENTER creates and stores the line.

- DATA** (PROG Mode) Used to enter a value for a data point at the address (selected by **ADRS**) in the arbitrary memory bank (selected by **PROG**). To enter a data point, press **DATA**, enter the data point value (**DATA** keypad), press **ENTER**. Data range: +2047 to -2047.
- START** (PROG Mode) Displays the address in arbitrary waveform memory at which arbitrary waveform execution will start. To change the **START** address, press **START**, enter the **START** address (**DATA** keypad numbers), press **ENTER**. Address range: 0 - 8191.
- STOP** (PROG Mode) Displays the address in arbitrary waveform memory at which the arbitrary waveform will stop and then return to the **START** address. To change the **STOP** address, press **STOP**, enter the **STOP** address (**DATA** keypad numbers), press **ENTER**. Address range 0 - 8191.

3 TRIG Keys

These keys select the trigger source used by the **TRIG**, **GATE**, and **BURST** modes.

- INT** Selects internal trigger source. **INT** can not be used in **ARB** or **Sweep** modes (Error codes 207 and 208). The rate of the trigger source is the last entered **RATE** parameter.
- EXT** Selects the external trigger signal applied to the front panel **TRIG IN** bnc connector.
- MAN** Selects a manual trigger/gate as the trigger source.
- EXEC** If **MAN** trigger is selected, and the **MODE** is:
- * **TRIG**--pressing **EXEC** triggers a signal one cycle in length.
 - * **GATE**--the output is enabled as long as the **EXEC** button is pressed.

- * **BURST**--pressing **EXEC** triggers an signal that is **N BURST** cycles in length.

4 MODE Keys

These buttons select the output mode. The **CONT**, **TRIG**, **GATE**, and **BURST** modes are mutually exclusive; the key **LED** lights to indicate the selected mode.

- CONT** Selects a continuous output.
- TRIG** Selects generation of one complete cycle of the selected waveform for each trigger received. Refer to the **TRIG KEYS** description.
- GATE** Selects output of complete cycles as long as the trigger source applied to the **TRIG IN** connector is asserted.
- BURST** Selects output of the number of cycles specified by **N BURST**, for each trigger received. The **N BURST** range: 1 - 9999.
- SWEEP** This key is used with the **DATA** keypad (0, 1, 4, 7) and the **START** and **STOP** keys to select a sweep function, as follows: press **SWEEP**, and one of the keypad numbers defined below, then **ENTER**. The sweep signal is output at the **SWEEP OUT** connector.
- Key 0 (**OFF**)--turns the sweep generator off.
 - Key 1 (**LIN**)--generates a linear sweep between the selected start and stop frequencies.
 - Key 4 (**LOG**)--generates a logarithmic sweep between the selected start and stop frequencies.
 - Key 7 (**ARB**)--uses a waveform in arbitrary waveform memory to control the frequency of the sweep signal.

- AM** Uses the signal applied to the AM IN connector to amplitude-modulate the output waveform.
- FM** Uses a signal applied to the VCO/FM IN connector to control the output waveform frequency, allowing FM modulation.
- SYNT** (Option 02 only) When this key is pressed, the instrument outputs a continuous waveform that is frequency-locked to an internal standard.

5 DATA Keys

The DATA keypad is used to enter numeric data. Some keys are dual function (see the SWEEP key description). Using the *MHz/V microsecond*, the *kHz/mV ms*, and the *Hz/s* keys allows the user to scale the input. A decimal point key and minus key are also included. The ENTER key is used to complete a numeric entry.

NOTE

If the function or parameter is selected, and no data is entered, the ENTER key will terminate the selection with no change to the value of the function or parameter.

If data has been entered, but the ENTER key has not been pressed, the operation may be aborted by pressing any key except DATA keys and INST ID.

6 INCREMENT Keys

The INCREMENT keys (up-arrow and down-arrow) modify the displayed value of the selected parameter. To use these keys to change a parameter value, press the parameter key and the INCREMENT up-arrow or down-arrow key. The step size is set by the INCR SIZE parameter key for each parameter (FREQ, AMPL, OFFSET, MARKER, N BURST, DC, and RATE).

7 SETUP Keys

These keys are used to save or recall front panel settings.

- STORE** Used with the DATA keypad to store the current front panel settings in a settings buffer. To store the current settings, press STORE, enter the number of the settings buffer (1-99) in which you want to store the settings, and press ENTER.

NOTE

Partially entered function or parameters will not be stored by the STORE function.

- RECALL** Used with the DATA keypad to recall previously stored front panel settings. To recall a stored setting, press RECALL, enter the number of settings buffer containing the desired settings, press ENTER. Entering RECALL 0, restores the front panel settings to the power-on values.

8 INST ID Key

Causes the AFG 5101/5501 to display its GPIB address, EOI/LF terminator (and, if enabled, to generate a service request (SRQ) over the GPIB). To display the GPIB address, press INST ID. To change the address or terminator, use SPCL key functions 240 and 241. Refer to *Special Functions*.

9 OUTPUT ON Key

Turns the main output of the instrument on (LED on) or off.

10 Connectors

TRIG IN	Couples the input for the trigger and gate functions.		
SYNC OUT	Couples an internal TTL level squarewave (at the programmed frequency) for external use.	SWEEP OUT	Outputs a sweep control voltage for use with devices such as an xy plotter.
MARKER OUT	During a sweep, this connector supplies a pulse when the marker frequency is reached.	VCO/FM IN	The input connector for the frequency modulation signal or the VCO input voltage.
GND	Supplies a ground for the HOLD input and the MARKER output.	AM IN	The input connector for the AM modulation signal.
HOLD IN	Couples an external TTL-compatible signal that stops and restarts arbitrary waveform execution. A TTL-high signal holds the output; a TTL-low signal releases it.	OUTPUT	The main generator output signal.

Operating Considerations

General Operating Information

Allow 30 minutes warmup time for operation to specified accuracy.

CAUTION

Observe the specified maximum input voltage ratings listed in the Electrical Specifications, in this manual. Instrument damage may occur if the maximum input ratings are exceeded.

Memory

The AFG 5101/5501 uses non-volatile internal memory to store arbitrary waveform memory bank data, and to store up to 99 front panel setups. The data is maintained in memory by internal battery backup. The AFG 5101/5501 warns of a low battery condition by displaying an error code in the display window. Since it is impossible to guarantee that stored data can not be lost, it is recommended that you maintain a record of data stored in memory so that you can manually restore such data, if necessary.

NOTE

Data stored in settings buffers and arbitrary waveform memory banks can also be sent to the controller and re-stored over the GPIB.

Output Connections

The AFG 5101/5501 output circuits are designed to operate as a 50 ohm voltage source working into a 50 ohm load. At higher frequencies, an unterminated or improperly terminated output will cause aberrations on the output waveform. Loads less than 50 ohms will reduce the waveform amplitude; loads more than 50 ohms will increase waveform amplitude.

Excessive distortion or aberrations, due to improper termination, are less noticeable at lower frequencies (especially with sine and square waveforms). To ensure waveform purity, observe the following precautions.

1. Use good quality 50 ohm coaxial cable and connectors.
2. Make all connections tight and as short as possible.
3. Use good quality attenuators if it is necessary to reduce waveform amplitudes applied to sensitive circuits.
4. Use terminations or impedance-matching devices to avoid reflections when using long cables (six feet or more).
5. Ensure that attenuators, terminations, etc., have adequate power handling capabilities for the output waveform.

If there is a dc voltage across the output load, use a coupling capacitor in series with the load. The time constant of the coupling capacitor and load must be long enough to maintain pulse flatness.

Impedance Matching

If the AFG 5101/5501 is driving a high impedance such as the 1 Meg-ohm input impedance (paralleled by a stated capacitance) of an oscilloscope vertical input, connect the transmission line to a 50-ohm attenuator, a 50-ohm termination, and then the oscilloscope input. The attenuator isolates the input capacitance of the device, and the AFG 5101/5501 is properly terminated.

Displayed Errors

When powered up, the AFG 5101/5501 performs a diagnostic self-test to check its functionality. If an error is found, an error code and text will be displayed in the display window. Other errors occur when the user attempts to make an invalid front panel setting. In this event, an error code and descriptive phrase are shown in the display window; the error can be cleared by pressing any key except INST ID. The AFG 5101/5501 automatically clears front panel errors after a timeout of about 9 seconds. Error code definitions are listed in Table 2-2.

Table 2-2
FRONT PANEL ERROR CODES

Code	Error Description
010	Incorrect syntax.
011	Increment step error.
012	Increment limit.
013	Decrement limit.
014	INCR/DECR error.
015	SPCL not exist.
016	Mode conflict.
204	Setting conflict.
205	Out of range.
207	ARB Internal-Trig conflict.
208	SWEEP Internal-Trig conflict.
250	AMPL OFFSET conflict.
251	DATA out of range.
253	INCREMENT out of range.
255	Bad settings buffer.
256	ADRS out of range.
261	SWEEP operation error.
262	Synthesizer not installed (Option 02 only).
270	N BURST out of range.
271	RATE out of range.
272	MARKER out of range.
273	FREQ out of range.
274	AMPL out of range.
275	OFFSET out of range.
276	START out of range.
277	STOP out of range.
280	DC out of range.
290	SYNThesizer illegal parameter.
340	Save RAM failure.
650	Low battery.
660	Output overload.

If no error is found during self test, the instrument enters the local state with the settings listed in Table 2-1.

Store/Recall Settings

The AFG 5101/5501 can store 99 front-panel setups in non-volatile memory; the stored setups can be recalled (front panel settings are changed to match the stored setup).

To store the current front panel settings in a settings buffer, press STORE, a settings buffer number (using the DATA keypad), then press ENTER. Settings buffers are numbered 0 through 99; settings buffer number 0 is a read-only buffer

that contains the power-on settings listed in Table 2-3. (At shipment, all buffers contain the power-on settings.)

The following front panel settings are not stored in settings buffers by the STORE function:

INCR SIZE
MARKER on/off (SPCL function 250)

The following settings are not stored in settings buffers by the STORE function, but are retained in non-volatile memory and used at power-on:

arbitrary waveform data (arbitrary waveform data is stored in a separate memory).
Display intensity/backlight (SPCL function 220)
GPIB address (SPCL function 240)
GPIB message terminator (SPCL function 241)

To recall a stored setup, press RECALL, the number of the buffer than contains the desired setup, and press ENTER.

Special Functions

The AFG 5101/5501 has a series of special functions that allow the user to change additional instrument settings. These functions are listed in the table below.

Table 2-3
SPECIAL FUNCTIONS

Code	Description
100	displays the instrument identification.
210	sets the units for the RATE parameter.
220	changes display intensity and turns backlighting on/off.
230	selects the frequency lock mode.
240	changes the GPIB address.
241	changes the GPIB message terminator.
250	turns frequency marker on/off.
260	turns the range lock mode on/off.
310	(PROG Mode only) Sets the automatic increment for the ADRS function on/off.
320	(PROG Mode only) Selects one of 5 predefined arbitrary waveform functions.
330	(PROG Mode only) Turns PROGRAM ARB on/off.
510	For use by qualified service personnel only.

To invoke a special function, press the SPCL key. Then, select the desired function by using either of the following methods:

- enter the special function code using the DATA keypad, and press ENTER, or
- press one of the INCREMENT keys to page through the displayed menu to the desired function.

Both the function name and its numeric code should now be displayed in the front panel window.

To use the selected special function, refer to the function description below, listed by code.

To exit a special function, press any FUNCTION or PARAMETER key.

- 100 Identifies the product type and displays the product version number, the firmware version number, and option number: TEK AFG 5101 V81.1 F1.0 OPT02. OPT02 indicates that the Option 02 synthesizer is installed; the option response is omitted if the instrument has no options. Version Fx.x is the firmware version installed in the instrument.
- 210 Allows the user to change the units for the RATE parameter. Units of measure can be time or frequency. Press an INCREMENT key to change the units selection, then exit. When the unit of measure is

changed, the RATE parameter reverts to the power-on value of the new units. Power-on setting: seconds

- 220 Allows the user to change the intensity level and enable or disable back-lighting; use the INCREMENT up and down arrow keys to increase or decrease the intensity of the characters; backlighting automatically toggles between ON and OFF each time the user presses ENTER. The intensity scale is 1 to 99. Settings are saved and used when powered-on.
- 230 Frequency lock mode selection. Press either INCREMENT key to toggle the frequency lock status between ON and OFF. Power-on setting: on.
- 240 This function allows the user to change the GPIB address from the front panel. Use the INCREMENT keys to increment or decrement the displayed address or use the DATA keypad to enter the address. The address selection is stored and used again when the instrument is powered on. Factory set address: 7.
- 241 This function allows the user to change the GPIB message terminator from the front panel. Use the INCREMENT up and down arrow keys to toggle between terminators. The terminator selection is stored and used again when the instrument is powered on. Factory set terminator: LF with EOI.

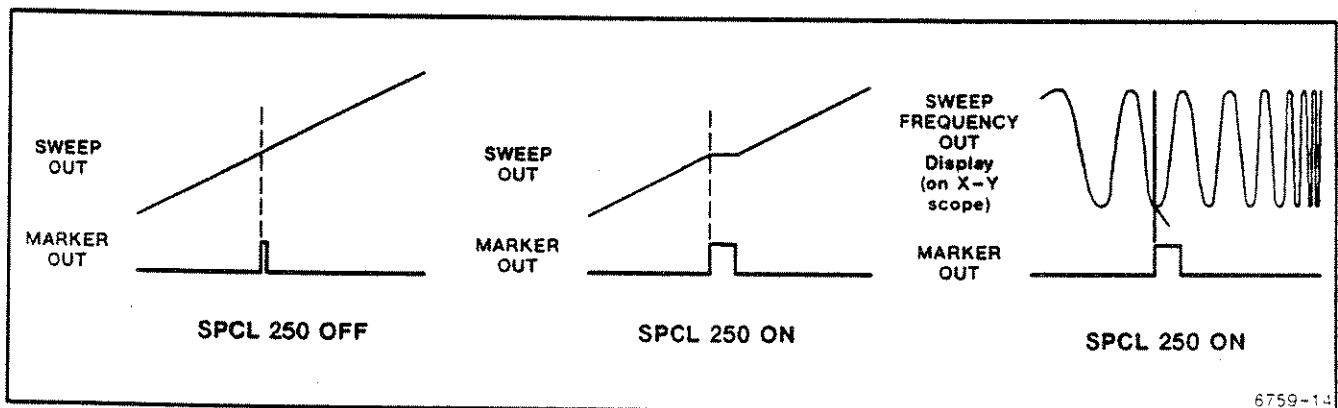


Fig. 2-6. SPCL 250 example.

- 250 Toggles the sweep marker function. With this function on, a horizontal line is inserted in the main output signal at the MARKER frequency and a pulse is output at the MARKER OUT connector; marker width is set by RATE. With SPCL 250 displayed, press either INCREMENT key to toggle the status. Power-on setting: off. Refer to Fig. 2-6.
- 260 Toggles the range lock function (to enable external wide sweep). With SPCL 260 displayed, press either INCREMENT key to toggle the status. Power-on setting: off.

Program Mode SPCL Functions

- 310 Turns on or off auto-increment for ADRS function. To turn the auto-increment on or off, press PROG and press DATA key 1 or 2 (to select memory bank to receive arbitrary waveform data), and press ENTER. Press SPCL and select function 310. The window displays ARB AUTO INCR; press ENTER. Display shows AUTO INCR. ON or OFF; press either INCREMENT key to change status. Power-on setting: on.
- 320 Selects one of 5 predefined arbitrary waveform functions. The predefined function (1000 points in length) is copied into arbitrary waveform memory bank, beginning at the last address entered. Key sequence: PROG, key 1 or 2 to select arbitrary waveform memory bank 1 or 2, ENTER; select START address; press SPCL, keys 320, ENTER; the window shows FUNC SELECT followed by SIN, SQR, TRN, RUP, or RDN; press one of the INCREMENT keys to change the displayed selection to the desired function, press ENTER, PROG. To output the waveform, press ARB.



Copying a predefined waveform to a memory bank will write over any arbitrary waveform data already stored in memory, beginning at the current arbitrary START address.

- 330 Allows the user to modify data in an arbitrary waveform memory bank while an arbitrary waveform is executing from that bank. With SPCL 330 on, the execution buffer is automatically updated when the

current execution cycle ends. This function must be turned on/off in the PROG mode; also, with SPCL 330 on, modification of the memory bank data is done with PROG on.

The memory bank selected for modification must be the same bank from which the arbitrary waveform is being executed.

To effect the executing waveform, the address of the modified data must be in the range of the executing waveform.

Example: Bank 1 is selected; START address is 100; STOP address is 200.

With PROGRAM ARB on, modifying data at address 250 in bank 1 will *not* change the executing waveform.

With PROGRAM ARB on, modifying address 150 in bank 2 will *not* affect the executing waveform.

With PROGRAM ARB on, modifying data in bank 1, address 150 will change the executing arbitrary waveform.

With SPCL 330 off, the contents of the execution buffer are not updated (re-written from the memory bank) until the ARB key is pressed.

Stepping a Parameter Level

The AFG 5101/5501 allows the user to step the level of the following parameters/functions, while the output waveform is being generated. Stepping is done by selecting the parameter/function, and pressing the INCREMENT up- or down-arrow key. The step size is determined by the INCR SIZE setting for the selected parameter.

- FREQ steps the waveform frequency
- AMPL steps the waveform amplitude
- OFFSET steps the offset voltage
- RATE steps the value used by RATE to control the sweep rate and the internal trigger rate.
- N BURST steps the number-in-burst value that controls the number of cycles generated in BURST mode.

MARKER steps the frequency set for the marker parameter.

DC steps the output voltage of the DC function.

The direction of step change is determined by the user: pressing the INCREMENT up-arrow key steps in a positive direction; the down-arrow key in a negative direction.

INCR SIZE operates in two modes. In the default mode, the AFG 5101/5501 automatically sets the value of INCR SIZE to the least significant digit of the range for the currently selected parame-

ter. When parameter selection changes, the value of INCR SIZE automatically changes accordingly.

In the non-default mode, the value of INCR SIZE is set by the user as follows: with the parameter to be stepped selected, press INCR SIZE, enter a step size using the DATA keypad, press ENTER. In this mode, step size is locked to the user-selected value until the user resets the step size to 0. Note that setting INCR SIZE to a value that is less than the least significant digit for the currently selected parameter range generates an error when the INCREMENT key is pressed.

Generating a Standard Output Function

The AFG 5101/5501 provides four standard output functions: sine-wave, triangle-wave, square-wave, and dc. To output a standard waveform function requires selecting the front-panel functions, parameters, modes, etc., and their values, that define the waveshape of the output signal. These

selections are presented in the following list, by general characteristic. The list is a guide to setting the controls to define a basic waveshape; additional settings are then described that add capabilities useful for special applications.

Table 2-4
GENERATING A STANDARD OUTPUT FUNCTION

Purpose	Step 1	Step 2
Select Output Function: (Press one)	SINE	
	TRIANGLE	
	SQUARE	
	DC	Enter dc voltage: (DATA numeric, units keys); press ENTER. Skip to Select Trigger Source.
Select Output Frequency:	FREQ	Enter frequency (DATA numeric, units keys); press ENTER.
Select Output Amplitude:	AMPL	Enter amplitude (DATA numeric, units keys); press ENTER.
Select Trigger Source: (Press one)	INT	Set internal trigger rate: (RATE, DATA numeric, units keys), ENTER.
	MAN	
	EXT	
Select Output Mode: (Press one)	CONT	
	TRIG	
	GATED	
	SYNT	
	BURST	Set number in burst: (N BURST, DATA numeric, units keys), ENTER.
Turn on output:	OUTPUT (LED on)	

Modulation

Two kinds of modulation can be used to alter the output waveform: frequency modulation, and amplitude modulation. For each, the appropriate external signal is applied to a special connector on the front panel. Refer to Specifications regarding limitations on external signals applied to the AM IN and VCO/FM connectors.

Frequency Modulation. A signal applied to the VCO/FM IN connector can modulate the frequency of the output waveform; the output signal becomes the FM carrier or a voltage-controlled frequency signal (VCF). The polarity of the external input signal determines the direction in which the output will deviate in frequency: a positive-going input signal increases output signal frequency. The amplitude of the external input signal determines the percent of frequency change in the output signal. A modulating signal will deviate the output frequency by approximately 1 percent per volt (maximum of 5 volts peak-to-peak).

The selected output frequency (FREQ key setting) is the "center" frequency above and below which frequency modulation swings. Although the AFG 5101/5501 is capable of three decades of sweep, the full 1200 : 1 frequency modulation is limited in that the generator can be swept only to the top of the sweep range within which the selected output signal frequency falls. The AFG 5101/5501 frequency ranges change at 12 in decade steps. For example, if the FREQ parameter is set to 11 MHz, the maximum positive frequency swing is 1 MHz.

In addition, the amount of deviation from the center frequency depends upon the position of that frequency in its range. For example, if the FREQ parameter is set to 11.5 MHz, the maximum frequency swing (in either direction) is 500 kHz.

Range lock can allow a wider frequency swing when using FM or VCO. This is done by setting the FREQ parameter to a frequency that is in a range that includes the highest frequency that will be output. Then turn on range lock (using SPCL function 260) to lock to the current range; the frequency will automatically be set to the lowest frequency in the range. Use the FM/VCO input signal to sweep the output frequency to the top of the range.

To enable frequency modulation, press the FM key (LED on).

Amplitude Modulation. A signal applied to the AM IN connector modulates the amplitude of the output waveform. Amplitude modulation effectively sums the amplitudes of the generator and the external signal applied to the AM IN connector.

A modulating signal of approximately 5 volts peak-to-peak will cause 100-percent modulation of the output if the output amplitude is set to 4.5 V peak-to-peak; if the output amplitude is greater than 4.5 V peak-to-peak, a 5 V modulating signal will cause clipping of the output signal. Refer to Table 1-10, AM INPUT, in the Specifications section.

To enable amplitude modulation, press the AM key (LED on).

Offset

The offset parameter can add a positive or negative dc level to the output waveform. Refer to the Electrical Specifications for combined output/offset level limitations.

To use OFFSET, press the OFFSET key, enter the offset voltage level, select units if appropriate, press ENTER. The OFFSET key LED is on while the offset level is not 0. To turn the offset off, repeat the process described above, setting the offset level to 0 (LED off). If an illegal offset combination is entered, an error will be generated.

Range Lock

Range lock limits frequency generation to the maximum and minimum frequencies of a specific frequency range. Range lock can be turned on or off by SPCL function 260. The power-on setting is range lock off.

To use range lock, set the FREQ parameter to a frequency in the desired range. (Refer to the Electrical Specifications in Section 1 of this manual for frequency ranges.) Then turn on range lock using the SPCL function.

Frequency Lock

With frequency lock on, internal circuitry improves the generator's frequency accuracy. For operation to specified frequency accuracy, frequency lock should be on. The default setting is frequency lock on. Frequency lock can be turned off by using a SPCL function. Refer to Special Functions in this section of the manual.

Synthesizer

The synthesizer mode is available only on instruments that include Option 02. The synthesizer outputs a continuous waveform that is frequency-locked to an internal quartz crystal. The display allows 4.5 digit resolution.

Storing an Arbitrary Waveform

The AFG 5101/5501 has two non-volatile memory banks that store arbitrary waveform data. Each memory is 8 k-points in length; each arbitrary waveform point is stored as a data value at an address in a memory bank. A series of data values in a memory bank comprise a waveshape that can be executed to generate an output waveform. The data value defines the relative amplitude of a point in an arbitrary waveform. The range of data values is from -2047 to +2047. The address range in each arbitrary waveform memory bank is 0 through 8191.

At execution, the amplitude of the generated arbitrary waveform can be scaled by the AMPL setting.

An arbitrary waveform can be created by storing

each data value at an address in a memory bank, one data value at a time, using front panel controls. A waveform can also be created by writing data values mathematically calculated by the AFG 5101/5501, to a memory bank. Or, a combination of these two methods of creating an arbitrary waveform can be used. The AFG 5101/5501 can calculate data values for 5 different wave shapes: sine, square, triangle, ramp-up, and ramp-down. These pre-defined waveshapes are 1000 points in length and consist of data values that span the maximum data value range.

The following table lists the actions required to store data values and predefined waveforms at specified addresses in the selected memory bank.

Table 2-5
STORING AN ARBITRARY WAVEFORM

Purpose	Step 1	Step 2
Select arbitrary PROG mode and memory bank:	PROG	Select memory bank: Enter the new bank number (1 or 2); ENTER.
Select arbitrary memory bank address:	ADRS	Enter address (DATA numeric keys); ENTER. (Range: 0 to 8191.)
Store data value. Choose method:		
1. Write a data value to selected address:	Input data value: (DATA numeric keys); ENTER. (Data range: -2047 to +2047)	Repeat last two steps (set address, store data value) for each non-adjacent data point; repeat <i>store data</i> for adjacent points.
2. Write a predefined waveform to selected address:	Select waveform: SPCL, 320, ENTER.	Press INCREMENT to page through displayed menu to desired waveform. Press ENTER to write a 1000-point waveform to the current memory bank, beginning at address previously entered via the ADRS key.
Exit PROG mode when arbitrary waveform programming is done.	PROG (LED off)	

Note that when the arbitrary waveform memory bank selection is changed, the address pointer is set to address 0.

Enabling/Disabling ADRS Auto-Increment

The ADRS auto-increment function is used when storing data values in an arbitrary waveform memory bank. With auto-increment turned on, the address pointer in the current memory bank increments to the next higher address after a data value is stored at the current address. Auto-increment can be turned on or off using SPCL function 310.

Using Autoline

The autoline function calculates the data values required to "draw" a straight line between the data values of the last two addresses entered and writes those values to the arbitrary waveform memory bank. To use AUTOLINE, follow the sequence listed below. (Italicized words identify front panel keys.)

Enter PROG mode:
PROG

Check the displayed memory bank selection:
Change the selection, if desired.
ENTER

Select address at which line will begin:
ADRS
Enter address, using *DATA* numeric keys.
ENTER

Enter a data value at that address:
DATA
Enter a data value, using *DATA* numeric keys.
ENTER

Select address at which the line will end:
ADRS
Enter address, using *DATA* numeric keys.
ENTER

Enter a data value at the end address:
DATA
Enter a data value, using *DATA* numeric keys.
ENTER

Draw line in memory bank:
AUTOLINE

ENTER

Exit PROG mode:
PROG

When the modified part of the arbitrary waveform is executed, the area between the two data points entered will show a line from the first data value to the second. Note that the slope of the line can be made positive or negative (slope is determined by the value of the two data points).

Arbitrary Waveform Programming Example

The following example steps through the actions necessary to create an arbitrary waveform in a memory bank. The example uses three methods to store data: by storing individual data values, by loading a predefined waveform, and by using AUTOLINE. Italicized words identify front panel keys.

Arbitrary Waveform Programming Example

Enter PROG mode:
PROG

Set memory bank selection to bank 1:
1
ENTER

Set ADRS pointer to address 0:
ADRS
0
ENTER

Write predefined sinewave to memory bank, beginning at address 0:
SPCL
3
2
0
ENTER
Display shows *FUNC SEL SINE*
ENTER

Draw line between addresses 250 and 750:
Enter first address:
ADRS
2
5
0
ENTER

Enter second address:

ADRS
7
5
0
ENTER

Set start address to 0:

START
0
ENTER

Draw line:

AUTOLINE
ENTER

Set stop address to 1000:

STOP
1
0
0
0
ENTER

Add pulse (data value +2047) at address 600:

ADRS
6
0
0
ENTER
DATA
2
0
4
7
ENTER

Exit PROG mode:

PROG

Execute arbitrary waveform output:

ARB
OUT

When arbitrary waveform memory between addresses 0 and 1000 executed, the generated waveform will resemble the waveform illustrated in Fig. 2-7.

To output the stored waveform, do the following steps:

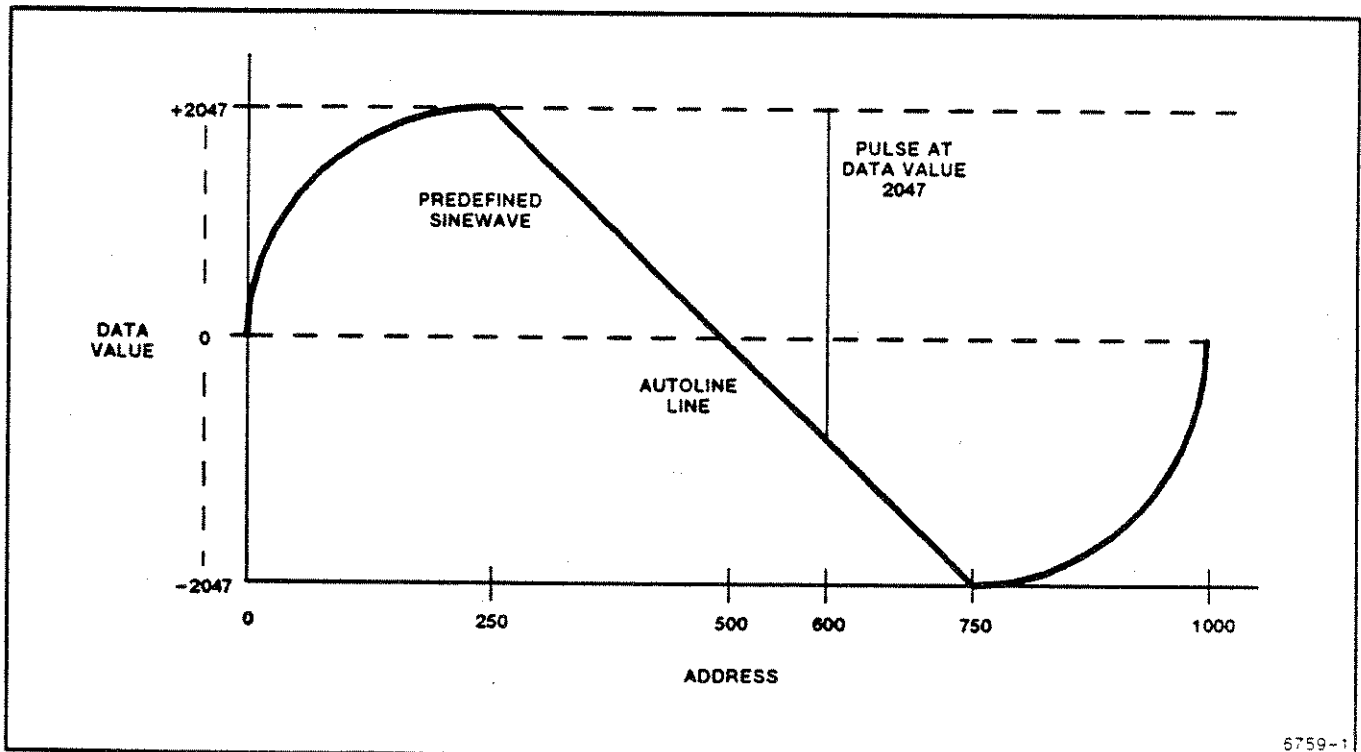


Fig. 2-7. Arbitrary waveform example final results.

Generating Arbitrary Waveform Output

After data values representing an arbitrary waveform are stored in a memory bank, all data in that bank can be executed. Or, a part of the stored arbitrary waveform data can be selected for execution. The area in the current memory bank that is defined for execution is copied to an execution buffer when ARB is pressed in the non-PROG mode, and then the waveform represented by that data is generated and output.

Defining a portion of arbitrary waveform data stored in a memory bank for execution requires setting the START and STOP addresses in PROG mode. (Two values are associated with each of these keys; one is a frequency set in the non-PROG mode and used to define a sweep range; the other values are addresses set in PROG mode and used to define the area in arbitrary waveform memory bank used for execution.)

The example below describes the steps required to generate an arbitrary waveform. The example assumes that data is already stored in a memory bank, as described in the Arbitrary Waveform Programming Example previously described.

Arbitrary Waveform Generation Example

Enter PROG mode and select memory bank:

PROG
1
ENTER

Set START address to 0:

START
0

ENTER

Set STOP address to 1000:

STOP
1
0
0
0
ENTER

Exit PROG mode:

PROG

Set amplitude:

AMPL
5
V

Set mode:

CONT

Turn main output on:

OUT (LED on)

Generate arbitrary waveform output:

ARB

Note that the INT trigger source can not be used when executing an arbitrary waveform.

Using the Sweep Generator

The AFG 5101/5501 also provides a sweep generator function that outputs the selected sweep waveform at the SWEEP OUT connector. Three types of sweep output are available: linear, logarithmic, or arbitrary. The first two waveshapes are internally calculated shapes. With a standard analog function selected for main output, any one of the three sweep waveshapes can be selected. With an arbitrary sweep selected, a scaled version of the arbitrary sweep waveform is provided at the SWEEP OUT connector.

The sweep time is controlled by the RATE setting; sweep width is controlled by the START and STOP frequency settings. When a linear or logarithmic sweep is selected, the instrument calculates the waveshape with a 1000-point length, between the current START and STOP frequencies. The 1000-point waveshape constitutes one sweep cycle; each point of the 1000 points in the cycle's waveshape is output at the rate set by the RATE function.

For example, a linear sweep with a START frequency of 10 kHz, a STOP frequency of 11 kHz, and a

RATE of 1 millisecond will generate a linear sweep between 10 and 11 kHz with a cycle of 1 second.

The START and STOP frequencies must be in the same sweep range; refer to sweep specifications in Section 1 for ranges. If START and STOP frequencies are not in the same sweep range, an error (261) is generated.

To select a sweep output, press SWEEP; then press

- 1, for a linear sweep
- 4, for a logarithmic sweep, or
- 7, for an arbitrary waveform sweep (with ARB on);

the press ENTER.

To turn off the sweep generator, select sweep output 0.

The following table lists the items that must be set to generate a sweep.

Table 2-6
Using the Sweep Generator

Purpose	Step 1	Step 2
Select sweep starting frequency:	START	Enter frequency at which sweep will start (DATA numeric, units keys), press ENTER. NOTE: The sweep start and stop frequencies must be in the same sweep range. See Specification section.
Select sweep stopping frequency:	STOP	Enter frequency at which sweep will stop (DATA numeric, units keys), press ENTER. If the stop frequency is below the start frequency, the sweep decrements.
Select sweep rate:	RATE	Input rate value (DATA numeric, units keys); press ENTER
Select SWEEP mode:	SWEEP	
Select sweep type: (Press one)	LIN (DATA key 1, press ENTER). LOG (DATA key 4, press ENTER). ARB (DATA key 7 (pre-programming required); press ENTER). No sweep (DATA key 0, press ENTER).	

Markers

The AFG 5101/5501 produces two types of sweep oriented markers: dynamic, and TTL.

For a TTL marker, the AFG 5101/5501 can be set to output a pulse (at the MARKER OUT connector) whenever the output frequency reaches the frequency set for the marker. The marker pulse is a positive, TTL-level pulse, with a duration equal to a minimum of one period of the RATE setting.

A dynamic marker is used to sweep a signal with an x-y oscilloscope; the marker changes the shape of the sweep signal at the SWEEP OUT connector, causing an intensified point at the marker frequency.

To set the marker frequency, press MARKER; enter the marker frequency using the DATA keypad numeric and units keys; press ENTER. The marker frequency must be within the selected sweep range (START and STOP frequencies).

PROGRAMMING

Introduction

This manual section provides the information required for programming the TEKTRONIX AFG 5101/5501 Programmable Arbitrary Function Generator via the IEEE-488 bus. The IEEE-488 interface function subsets for the AFG 5101/5501 are listed in Section 1. In this manual, the IEEE-488 digital interface is called the General Purpose Interface Bus (GPIB). Message protocol over the GPIB is specified and described in the IEEE-Standard 488-1978, *Standard Digital Interface for Programmable Instrumentation*.

The information in this section assumes that the reader is knowledgeable in GPIB bus communication and has some experience in programming the system.

IEEE-728 Standard (the IEEE recommended practice for code and format conventions for use with IEEE-488) is used in programming the AFG 5101/5501. TM 5000 instruments are designed to communicate with any bus-compatible controller that can send and receive ASCII messages (commands) over the IEEE-488 bus. These commands program the instruments or request information from the instruments.

Recommended controllers for use in programming the AFG 5101/5501 are the Tektronix 4041; or an IBM PC-compatible, such as the Tektronix PEP 301, with the Tektronix GURU (GPIB User's Resource Utility for the IBM P.C.) software and GPIB interface card.

Commands for TM 5000 programmable instruments are designed for compatibility among instrument types. The same commands are used in different instruments to control similar functions. In addition,

commands are specified in mnemonics that are related to the functions implemented. For example, the INIT command initializes instrument settings to their power-on states.

Instrument commands are presented in this manual section in three formats:

- * A front panel illustration—showing command relationships to front panel operation. See Fig. 3-1.
- * Functional Command List—a list divided into functional groups with brief descriptions.
- * Detailed Command List—an alphabetical listing of commands with complete descriptions.

TM 5000 programmable instruments connect to the GPIB through a TM 5000 power module. Refer to the Operating Instructions section of this manual for information on installing the instrument in the power module. Also review this section for instrument caution and warning statements and to become familiar with front panel instrument functions.

The AFG 5101/5501 is shipped with the primary GPIB address set to 7. TM 5000 instruments are shipped with the message terminator set to LF with EOI. (Message terminators are described in Messages and Communications Protocol (in this section) The address and terminator settings are stored in non-volatile RAM. To display the current address and terminator, press the INST ID key. The GPIB primary address and message terminator can be changed using SPCL Functions (SPCL Functions are front panel key operations). For information, refer to SPCL Functions in the Operating Instructions section in this manual.

Commands

The instrument is controlled by the front panel keys or via commands received from the controller. These commands are of three types:

- * Setting commands—control instrument settings.
- * Query/Output—request data.
- * Operational—cause a particular action.

When the instrument is in the remote state, it provides a response or executes all commands as appropriate. In the local state, only query/output commands are executed; setting and operational commands generate error responses, since instrument functions are under front panel control.

Command Functional Groups

The following list of commands is arranged by functional group; some functional group lists are also divided into sub-groups.

INPUT/OUTPUT CONTROL COMMANDS

AM ON|OFF

Enables/disables use of the signal applied to the AM IN connector to amplitude-modulate the main output signal.

AM?

Returns the amplitude modulation mode status.
Response: AM ON;, or AM OFF;

FM ON|OFF

Enables/disables the use of a signal applied to the VCO/FM IN connector to modulate the frequency of the main output signal.

FM?

Returns the frequency modulation mode status.
Response: FM ON;, or FM OFF;

OUTput ON|OFF

Connects/disconnects the main output signal to the front-panel OUTPUT connector.

OUTput FLOAT

Disconnects the main output signal from the front panel OUTPUT connector and terminates it into a high impedance (floating).

OUTput?

Returns the output signal status (OUT ON, OUT OFF, or OUT FLOAT).

INSTRUMENT COMMANDS

Store/Recall

RECALL <bufnum>

Changes the instrument front panel settings to those recalled from the specified settings buffer (<bufnum>). Buffer 0 is a read-only buffer that contains the power-on settings. Buffer numbers: 0 - 99.

SEND? <bufnum>[,<bufnum>]...

Returns the stored settings from the specified buffer(s). Buffer 0 is a read-only buffer that contains the power-on settings; attempting to store settings in buffer 0 generates an error. Query response: STORE <num>:<binblk>[,<num>:<binblk>]...;

SEND? ALL

Returns the contents of all stored setting locations, beginning with buffer 0. Response: STORE ALL: <binblk>...<binblk>;

STORE <bufnum>[:<binblk>[,<bufnum>:<binblk>]]...

Saves the current front panel settings in a specified buffer(s) (<bufnum>) for later recall. Optionally stores the settings data defined in *binblk* in the specified buffer. <bufnum>: 1 - 99.

STORE ALL: <binblk>...<binblk>

Sequentially stores each front panel setup defined in *binblk* in a settings buffer, beginning with buffer 1.

Function

FUNCTION SINE

Selects the sine waveform for output.

FUNCTION SQUARE

Selects the square waveform for output.

FUNCTION TRIANGLE

Selects the triangle waveform for output.

FUNCTION DC

Selects dc output at the current value of the DC parameter.

FUNCTION ARBITRARY

Selects the arbitrary waveform stored in the currently selected arbitrary waveform memory bank for output.

FUNC?

Returns the output waveform selection status. Response: FUNC SINE;, FUNC SQUARE;, FUNC TRIANGLE;, FUNC DC;, or FUNC ARBITRARY;

DC [<volts>]

Selects dc output at the current value of the DC parameter, or at the level specified by the optional argument.

DC?

Returns the current setting of the DC output function.

Parameter

AMPLitude <amplitude in volts>

Sets the peak-to-peak output voltage (into 50 ohms) to the value specified by the argument.

AMPL?

Returns the current output amplitude. Response: AMPL <num>;

DISPlay <parameter>

Changes the display to show the parameter specified in the argument and its current value. Parameter: FREQuency, AMPLitude, OFFSet, NBUSt, or RATE.

DISPlay?

Returns the parameter that is currently shown in the display window. Response: FREQ;, AMPL;, OFFS;, NBUSt;, or RATE;

FREQuency <freq>[:<units>]

Sets the output frequency to the argument value.

FREQ?

Returns the current output frequency. Response: FREQ <num>;

NBUSt [<num>]

Sets the number of cycles for output in burst mode.

NBUSt?

Returns the current number of cycles set for the NBUSt command. Response: NBUSt <num>;

OFFSet <offset in volts>

Sets the open-circuit offset voltage to the argument value in volts. Argument 0 turns the offset off.

OFFSet?

Returns the current offset setting. Response: OFFS <num>;

RATE <num>[:<units>]

Sets the internal trigger interval.

RATE?

Returns the current internal trigger interval. Response: RATE <num>:<units>;

Trigger Mode

FRQLck ON|OFF

Enables/disables internal software control of the output frequency.

FRQLck?

Returns the status of the frequency lock mode. Response: FRQL ON;, or FRQL OFF;

MODE BURST

Selects the burst trigger mode.

MODE CONT

Selects continuous output mode.

MODE GATED

Selects the gated trigger mode.

MODE TRIG

Selects triggered output mode.

MODE SYNT

Selects the frequency lock mode (Option 02), with continuous output only.

MODE?

Returns mode status. Response: MODE CONT;, MODE TRIG;, MODE BURST;, MODE SYNT;, or MODE GATE;

Trigger Source

TRIG INT

Selects the internal trigger as trigger source.

TRIG EXT

Selects the external trigger as trigger source.

TRIG MANuAl

Selects the manual trigger function as the trigger source.

TRIG?

Returns the trigger source setting. Response: TRIG INT;, TRIG EXT; or TRIG MAN;

Sweep Function

FRQMARK <freq>[:<units>]

Sets the frequency at which a marker will be output. A frequency of 0 disables the marker output. Default units: Hz.

FRQMARK?

Returns the marker frequency setting. Response: FRQMARK <num>;

FRQSTART <freq>[:<units>]

Sets the sweep start frequency. If the start frequency is greater than the stop frequency, a decrementing sweep is generated. Default units: Hz.

FRQSTART?

Returns the sweep start frequency in Hz. Response: FRQSTART <num>;

FRQSTOP <freq>[:<units>]

Sets the sweep stop frequency.

FRQSTOP?

Returns the sweep stop frequency in Hz. Response: FRQSTOP <num>;

RNGLCK ON|OFF

Locks or unlocks the frequency range. When

RNGLCK ON is executed, the frequency range is locked to the current range and the internal output frequency is set to 0 Hz (or the lowest frequency). Only RNGLCK OFF releases the frequency lock.

RNGLCK?

Returns the range lock status. Response: RNGLCK ON;, or RNGLCK OFF;

SWEEP LIN

Sets the sweep shape to linear.

SWEEP LOG

Sets the sweep shape to logarithmic.

SWEEP ARB

Sets the sweep shape to the arbitrary waveform memory bank data defined by ARBSTART, ARBSTOP, and ARBSEL.

SWEEP OFF

Disables the sweep operation.

SWEEP?

Returns the selected sweep output status. Response: SWEEP LIN;, SWEEP LOG;, SWEEP ARB;, or SWEEP OFF;

Arbitrary Waveform

ARBADRS <address>

Moves the arbitrary waveform pointer to the specified memory address in the currently selected arbitrary waveform memory bank. Address range: 0 - 8191.

ARBADRS?

Returns the current arbitrary waveform pointer address in the currently selected arbitrary waveform memory bank. Response: ARBADRS <address>;

ARBCLR ALL| <start address>, <stop address>

Sets the data stored at all addresses, or at all addresses between those specified, to 0 (including start and stop addresses).

ARBDATA <data>[, <data>]...| <binblk data>

Sends data to the current arbitrary waveform pointer address in the currently selected arbitrary waveform memory bank. Address automatically increments to store additional data points.

ARBDATA? [<number of points>]:<A|B>

Returns the data at the current arbitrary waveform address (set by ARBADRS) and optionally, data for all points beginning at that address and sequential addresses incremented up to <number of points>. Switch A returns data in ASCII; B, in binary block format. Response: ARBDATA <data>[,<data>]...|<binblk data>;

ARBHOLD ON|OFF

When the *on* argument is received, execution of an arbitrary waveform stops. When *off* is subsequently received, execution restarts at the stopping address plus 1.

ARBHOLD?

Returns the ARBHOLD status. Response: ARBHOLD ON;, or ARBHOLD OFF;

ARBLOAD SINE

Loads a sine wave into the current arbitrary waveform memory bank (1000 address points in length), beginning at the current ARBADRS address.

ARBLOAD SQUARE

Loads a square wave into the current arbitrary waveform memory bank (1000 address points in length), beginning at the current ARBADRS address.

ARBLOAD TRIangle

Loads a 1000 point triangle waveform into the current arbitrary waveform memory bank, beginning at the current ARBADRS address.

ARBLOAD UP RAMP

Loads a positive-going ramp (1000 points in length) into the current arbitrary waveform memory bank, beginning at the current ARBADRS address.

ARBLOAD DN RAMP

Loads a negative-going ramp (1000 points in length) into the current arbitrary waveform memory bank, beginning at the current ARBADRS address.

ARBPROG ON|OFF

Enables or disables the capacity to update an executing arbitrary waveform when the arbitrary memory is modified. When ARBPROG is ON, the execution buffer is updated at the end of the current execution cycle. With ARBPROG OFF, update occurs when FUNC ARB is received.

ARBPROG?

Returns the current status of ARBPROG. Response: ARBPROG ON;, or ARBPROG OFF;

ARBSElect <banknum>

Selects the arbitrary waveform memory bank (1 or 2) to be used in arbitrary waveform operations. Changing the memory bank selection also sets the address pointer to address 0 (ARBADRS 0;).

ARBSElect?

Returns a number indicating which arbitrary waveform memory bank is currently selected. Response: ARBSEL <num>;

ARBSTART <address of start point>

Selects the address in the current arbitrary waveform memory bank at which arbitrary waveform execution will start.

ARBSTART?

Returns the address in the current arbitrary waveform memory bank at which arbitrary waveform execution will start. Response: ARBSTART <address>;

ARBSTOP <address of stop point>

Selects the address in the current arbitrary waveform memory bank at which arbitrary waveform execution will stop.

ARBSTOP?

Returns the address in the current arbitrary waveform memory bank at which arbitrary waveform execution will stop. Response: ARBSTOP <address>;

AUTOLINE [[<start address>,<start data>],<end address>,<end data>]

Computes a "line" from the current ARBADRS address and data value to the AUTOLINE argument address and its data value; the computed line data are stored in the current arbitrary waveform memory bank. Optionally computes a line between the addresses specified in the argument, using the argument data. If no addresses are given, the line is created between the two last addresses entered and their data. If only one address/data set is given, the line is computed between this data and the last-entered ARBADRS address/data set.

FILTER OFF|0|1|2|3|4

Selects one of four fixed, low-pass filters for application to an arbitrary waveform output.

Argument	Typical Cut-off Frequency
OFF or 0	no filter.
1	1 MHz
2	100 kHz
3	11 kHz
4	1.3 kHz

FILTER?

Returns the current filter selection. Response: FILTER <num>;

SYSTEM COMMANDS

DT TRIG

On receipt of a <GET> interface message, triggers the instrument to output a one-cycle waveform if in TRIG mode, or a burst of cycles if in BURST mode.

DT GATE

Toggles the gate setting on receipt of a <GET> interface message when in the MODE GATE trigger mode.

DT SET

Causes the instrument to wait for a <GET> interface message before updating the instrument settings.

DT OFF

Disables Trigger and Gate <GET> function; no response to <GET>; allows the instrument to update its settings without waiting for <GET>.

DT?

Queries the device trigger status. Response: DT GATE;, DT SET;, DT TRIG;, or DT OFF;

ERRor? or EVENT?

Returns an error code that matches the last SRQ that was polled with RQS ON, or the highest priority error in the error queue if RQS is OFF. ERR 0 indicates that there are no errors in the error queue. Response: ERR <num>; or EVENT <num>;

ERRM?

Returns the error code and the associated text shown in the front panel window that describes the current error. The returned code and text

matches the last SRQ that was polled with RQS ON, or the highest priority error in the error queue if RQS is OFF. ERR 0 is returned if there are no errors in the error queue. Response: ERRM <error #>, <error message>;

HELP?

Returns all AFG 5101/5501 commands.

ID?

Returns the identification of the instrument in the form: ID TEK/<model number>, <Tek Codes and Format version>, <firmware version>, <installed options>;

INIT

Returns all settings to the power-on state, except: stored settings and arbitrary waveform memory bank addresses and data.

SET?

Returns all instrument settings that can be set and queried except: stored front panel settings, and arbitrary waveform memory bank addresses and data.

TEST?

Executes internal checkout routines. Failure produces an error code in the response. A response of 0 indicates that the test was successful; 1 indicates a failure. Response: TEST <num>;

STATUS COMMANDS

OPC ON|OFF

Enables/disables the Operation Complete service request. If enabled and RQS is ON, and MODE TRIG or MODE BURST is selected, the instrument asserts SRQ at completion of an arbitrary waveform sweep, or of one execution of the arbitrary waveform execution buffer.

OPC?

Returns the Operation Complete service request status. Response: OPC ON;, or OPC OFF;

RQS ON|OFF

Enables/disables service request operation. If RQS is ON, errors are reported using SRQ at the end of command execution; if OFF, errors are queued until an error query is sent or until RQS is turned back on.

RQS?

Returns the RQS status. Response: RQS ON;, or RQS OFF;

USEReq ON|OFF

Enables/disables SRQ when the INST ID front panel key is pressed.

USER?

Returns the status of the USER REQUEST setting. Response: USER ON;, or USER OFF;

Control/Command Associations

Figure 3-1 shows the AFG 5101/5501 front panel key and command relationships.

Detailed Command Descriptions

Each AFG 5101/5501 command, like those in all TM 5000 instruments, begins with a header, which is a word or acronym that describes the function implemented. Following the header, many commands require an argument, which is a word or number that specifies the desired state for the function. The commands are presented alphabetically on the following pages. In this presentation, the following notations are used to represent elements of the IEEE-488 bus communications between the AFG 5101/5501 and the controller.

<GET> -- The Group Execute Trigger interface message (decimal code 8 transmitted with attention asserted). Only addressed listeners respond to **<GET>**.

<num> -- A number that can be transmitted or accepted by the AFG 5101/5501. Numbers may be NR1 (integer), NR2 (decimal), and NR3 (with exponent) formats. (See ANSI Standard X3.42.) Carets (**<** and **>**), are not part of the format; they are used in this manual to enclose an element for which the user must substitute the appropriate characters.

: -- Command argument link data. Data that is linked to the previous argument uses the colon (**:**) as the delimiter.

Example:

STOR 3:<binblk>

The buffer number 3 is linked to the buffer data (<binblk>).

<binblk> -- A Binary Block of data in the format specified in Tektronix Codes and Formats (V79.1). The binary block consists of the percent sign (**%**, decimal 37) followed by a two-byte binary count, the data bytes, and then ends with a checksum byte. The two-byte binary count (integer, most significant byte first) specifies the number of data bytes plus the checksum byte. The checksum is the two's complement of the modulo-256 sum of the preceding binary data bytes and the binary count bytes, but does not include the percent sign. The format for the data points is 2 bytes per point--high byte followed by low byte.

Carets (**<** and **>**) are not part of the format; they are used in this manual to enclose an element for which the user must substitute the appropriate characters.

| -- A vertical line is used in a series of two or more units, to separate the units; any one unit must be selected and sent as part of the command message. Do not include the line in the message.

[and] -- Square brackets enclose an optional message part. Do not include the square brackets in the message.

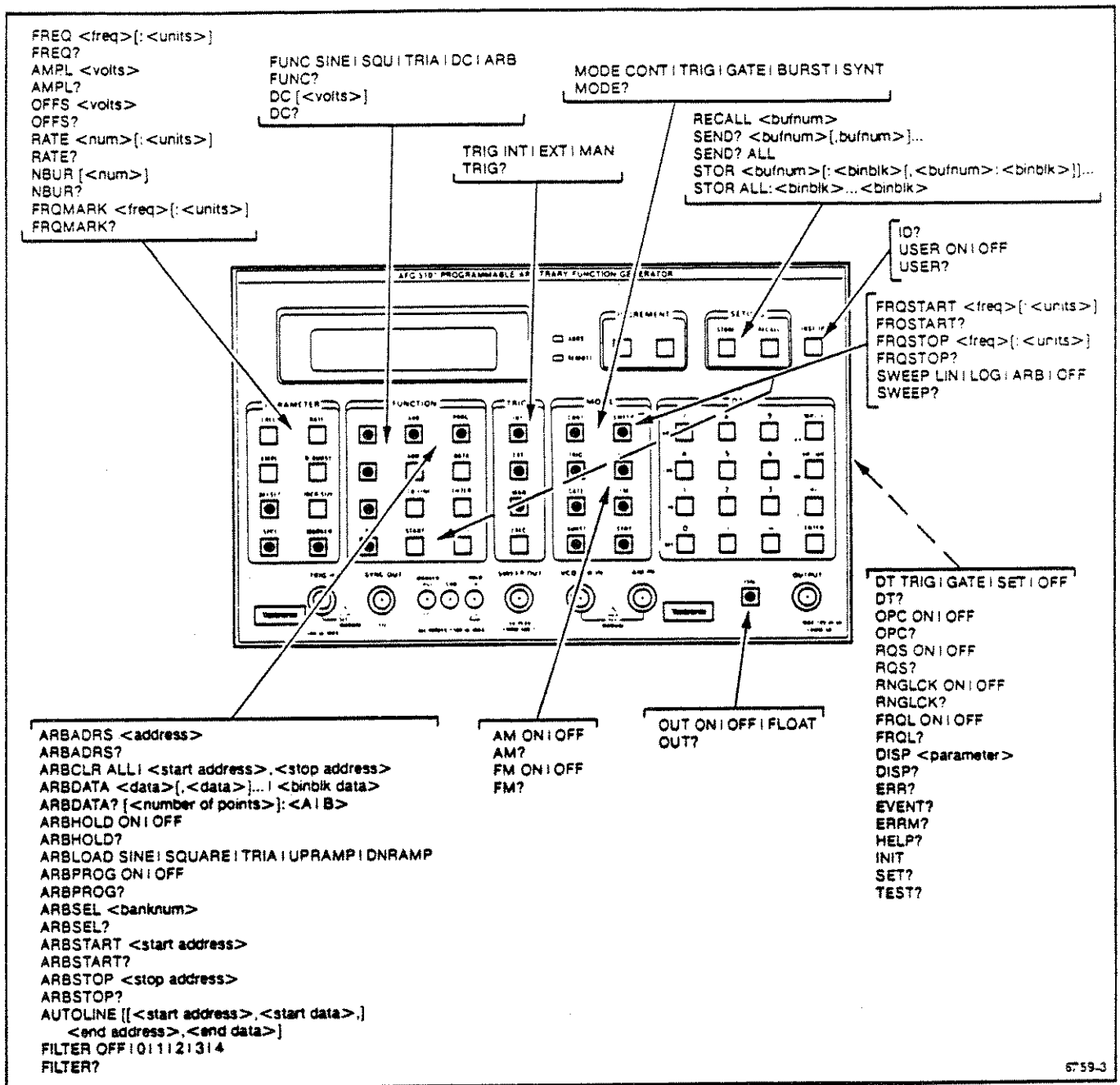


Fig. 3-1. Command associations to controls.

Detailed Command List

AM (Amplitude Modulation)

Command Type:
Setting or query

Setting Syntax:
AM ON|OFF

Examples:
AM ON
AM OFF

Query Syntax:
AM?

Query Response:
AM ON;
AM OFF;

Discussion:

The *on* argument causes the instrument to use the signal at the AM IN connector to amplitude-modulate the main output signal. Amplitude modulation effectively controls the peak-to-peak amplitude of the main output using the external signal applied to the AM IN connector.

A modulating signal of approximately 5 volts peak-to-peak will cause 100-percent modulation of a 4.5V p-p output signal; an external input signal over 5 volts peak-to-peak will distort the main output. Refer to Electrical Specifications for limitations on amplitude modulation and the modulating signal.

The *off* argument turns off amplitude modulation.

The query returns the status of amplitude modulation.

AMPL (Amplitude)

Command Type:
Setting or query

Setting Syntax:
AMPLitude <amplitude in V p-p>

Examples:
AMPLITUDE 8
AMPL 2.5

Query Syntax:
AMPL?

Query Response:
AMPL <num>;

Discussion:

The AMPL command sets the peak-to-peak output voltage into 50 ohms to the value specified by the argument. The argument is specified in volts. The power-on setting is 5 V.

The argument range is 10 mV to 9.99 V p-p into 50 ohms. The argument resolution is 1 mV when the amplitude is less than 1.0V, and 10 mV when the amplitude is greater than or equal to 1V.

Refer to the discussion on the OFFSET command for a more complete description of the relationship between amplitude and offset commands.

ARBADRS (Arbitrary Address)

Command Type:
Setting or query

Setting Syntax:
ARBADRS <address>

Examples:
ARBADRS 2150

Query Syntax:
ARBADRS?

Query Response:
ARBADRS <address>;

Discussion:

The ARBADRS command sets a pointer in the current arbitrary waveform bank at the address specified by the argument. Each bank has an address range of 0 to 8191. This command is used to set the target address for a data point or the starting address for a series of data points. The power-on pointer address is 0.

If the argument is out of the address range, an execution error occurs and the instrument asserts SRQ; the pointer location remains unchanged.

When the arbitrary waveform memory bank selection is changed (using ARBSEL), the address pointer is automatically moved to address 0.

ARBCLR (Arbitrary Clear)

Command Type:
Setting

Setting Syntax:
ARBCLR ALL| <start address>, <stop address>

Examples:
ARBCLR ALL
ARBCLR 2150,2160

Discussion:

This command sets the data stored in the current arbitrary waveform memory bank at the specified addresses to 0, including the data at the start and stop address points.

The ALL argument clears all data points in the current arbitrary waveform memory bank (0 - 8191).

ARBDATA (Arbitrary Data)

Command Type:

Setting or query

Setting Syntax:

ARBDATA <data>[,<data>]...|<binblk>

Examples:

ARBDATA 0000,0100,0200,0300,0400,0500,0600
ARBDATA 0000,-0500,-1000,-1500,-2000,0000
ARBDATA %<bytecount> <data> <checksum>

Query Syntax:

ARBDATA? <number of points>:<A/B>

Query Response:

ARBDATA <data>[,<data>]...|<binblk>;

Discussion:

ARBDATA is used to enter data at the current address in the current arbitrary waveform buffer.

If more than one data point is sent, the address is automatically incremented until all data points are stored. If the address increments out of limits, that data point and any additional data points are refused and SRQ is asserted after the command is executed; data entered up to the out-of-limits address remains in memory.

If the first character of the data stream is a % (per cent) sign, the next data is accepted in binary block format.

The range of data is from +2047 to -2047 in ASCII, and 0 to 4095 in binary block format.

The query response is sent in ASCII if "A" is sent; binary block format if "B" is sent. If data for only one point is requested, the instrument sends the data from the current pointer address in the current arbitrary waveform buffer; if data for more than one point is requested, then data is sent from the current pointer address and sequential addresses (incremented) to supply the number of points requested.

ARBADRS can be used to set the address pointer; ARBSEL selects the arbitrary waveform buffer.

CAUTION

If a front panel key is pressed during an ARB-DATA transfer, that transfer will be terminated, the instrument will go to the Local state, and the transferring waveform will be truncated.

NOTE

If data is sent or received using binary block, the GPIB termination should be EOI only. This terminator selection prevents a line feed <LF> in the data from terminating the transfer before all of the data is sent.

ARBHOLD (Arbitrary Hold)

Command Type:
Setting or query

Setting Syntax:
ARBHOLD ON|OFF

Examples:
ARBHOLD ON
ARBHOLD OFF

Query Syntax:
ARBHOLD?

Query Response:
ARBHOLD ON;
ARBHOLD OFF;

Discussion:

The *on* argument stops execution of an arbitrary waveform without exiting the arbitrary waveform execution mode. Execution is stopped at the arbitrary waveform buffer address being executed when the ARBHOLD command is executed. The *off* argument restarts arbitrary waveform execution at the stopped address. The next positive transition of the RATE clock will output the next arbitrary point. ARBHOLD is NOT reset to the *off* state by sending FUNC ARB; only the ARBHOLD ON or ARBHOLD OFF, INIT, or RECALL commands affect ARBHOLD status. Refer to Fig. 3-2.

ARBLOAD (Arbitrary Load)

Command Type:
Setting

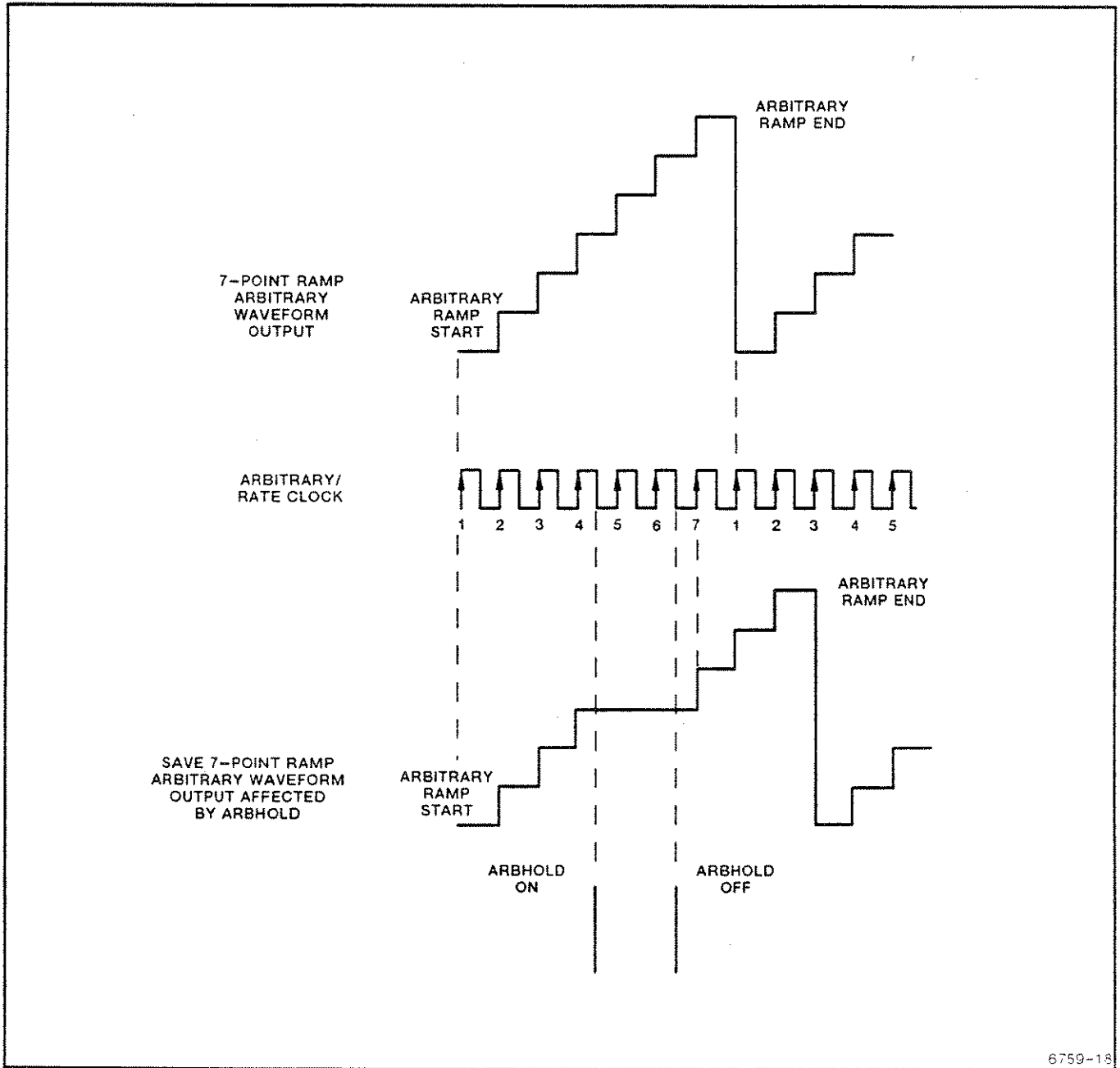
Setting Syntax:
ARBLOAD SINE
ARBLOAD SQUARE
ARBLOAD TRIAngle
ARBLOAD UPRAMP
ARBLOAD DNRAMP

Examples:
ARBLOAD SINE
ARBLOAD SQUARE
ARBLOAD TRIA
ARBLOAD UPRAMP
ARBLOAD DNRAMP

Discussion:

This command loads the current arbitrary waveform memory bank with a 1000-point waveform of the type specified by the argument. The waveform data values are from -2047 to +2047.

The START point is the address pointed to by ARBADRS. If the STOP point is greater than 8191, the waveform is truncated and an error is generated.



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Fig. 3-2. Relationship between arbitrary waveform output, ARBHOLD, and the RATE clock.

ARBPROG (Arbitrary Program Mode)

Command Type:
Setting or query

Setting Syntax:
ARBPROG ON
ARBPROG OFF

Examples:
ARBPROG ON
ARBPROG OFF

Query Syntax:
ARBPROG?

Query Response: (one of the following)
ARBPROG ON;
ARBPROG OFF;

Discussion:

This command enables or disables the capability to have changes to the current arbitrary waveform execution buffer immediately reflected in an executing waveform. For a change in data to show up in an executing waveform with ARBPROG ON, the following conditions must be met:

- * The address of the data must be between the START and STOP addresses.
- * And, the executing waveform must be derived from the currently selected waveform memory bank.

With ARBPROG ON, the execution buffer is automatically updated when the current execution cycle ends, except that the ARBSEL, ARBSTART, and ARBSTOP commands do not cause an immediate update.

With ARBPROG OFF, the execution buffer is not updated until the instrument receives FUNC ARB.

The query returns the status of the ARBPROG command.

ARBSELECT (Arbitrary Select)

Command Type:
Setting or query

Setting Syntax:
ARBSElect <banknum >

Examples:
ARBSEL 1
ARBSELECT 2

Query Syntax:
ARBSEL?

Query Response:
ARBS <num >;

Discussion:

This command selects one of the two arbitrary waveform memory banks as the current (active) bank. The current bank is used in all arbitrary waveform operations.

When the bank selection is changed, the ARBADRS pointer is reset to address 0.

The power-on/default setting is buffer 1.

Commands that operate on the current buffer are:

ARBCLR
ARBSTART
ARBSTOP
ARBADRS
GETARB
ARBLOAD
FUNC ARB
SWEEP ARB

ARBSTART (Arbitrary Start)

Command Type:

Setting or query

Setting Syntax:

ARBSTART <start point address>

Examples:

ARBSTART 1100

Query Syntax:

ARBSTART?

Query Response:

ARBSTART <num>;

Discussion:

This command selects the address in the current arbitrary waveform memory bank that will be the first point executed when arbitrary waveform output is initiated.

The power-on/default setting is ARBSTART 0.

ARBSTOP selects the last point in the waveform.

ARBSTOP (Arbitrary Stop)

Command Type:

Setting or query

Setting Syntax:

ARBSTOP <stop point address>

Examples:

ARBSTOP 2047

Query Syntax:

ARBSTOP?

Query Response:

ARBSTOP <num>;

Discussion:

This command selects the address in the current arbitrary waveform memory bank that will be the last point executed in an arbitrary waveform.

The power-on/default setting is ARBSTOP 8191.

ARBSTART selects the first point in the waveform.

AUTOLINE

Command Type:
Setting

Setting Syntax:

AUTOLINE [[<start address>,<start data>] <end address>,<end data>]

Examples:

AUTOLINE
AUTOLINE 8191,0
AUTOLINE 4000,2047,6000,-2047

Discussion:

This command computes a "line" in the current arbitrary waveform memory bank from the current pointer address (ARBADRS) to the AUTOLINE argument end address, and writes that data to the current arbitrary waveform memory bank. To create a line from the last address entered to a new point (Fig. 3-3, example 2), use:

AUTOLINE <end address>,<end data>;

The end address is the end of the "line"; end data is the data specified by the argument and stored at the end address.

Optionally computes a line between the addresses specified in the argument, using the argument data. (Refer to Fig. 3-3, example 3.)

If no argument is specified, AUTOLINE uses the last two addresses (and data) stored. Refer to Fig. 3-3, example 1.

After AUTOLINE is executed with arguments, the pointer in the current arbitrary waveform memory bank points at the end address of the line + 1.

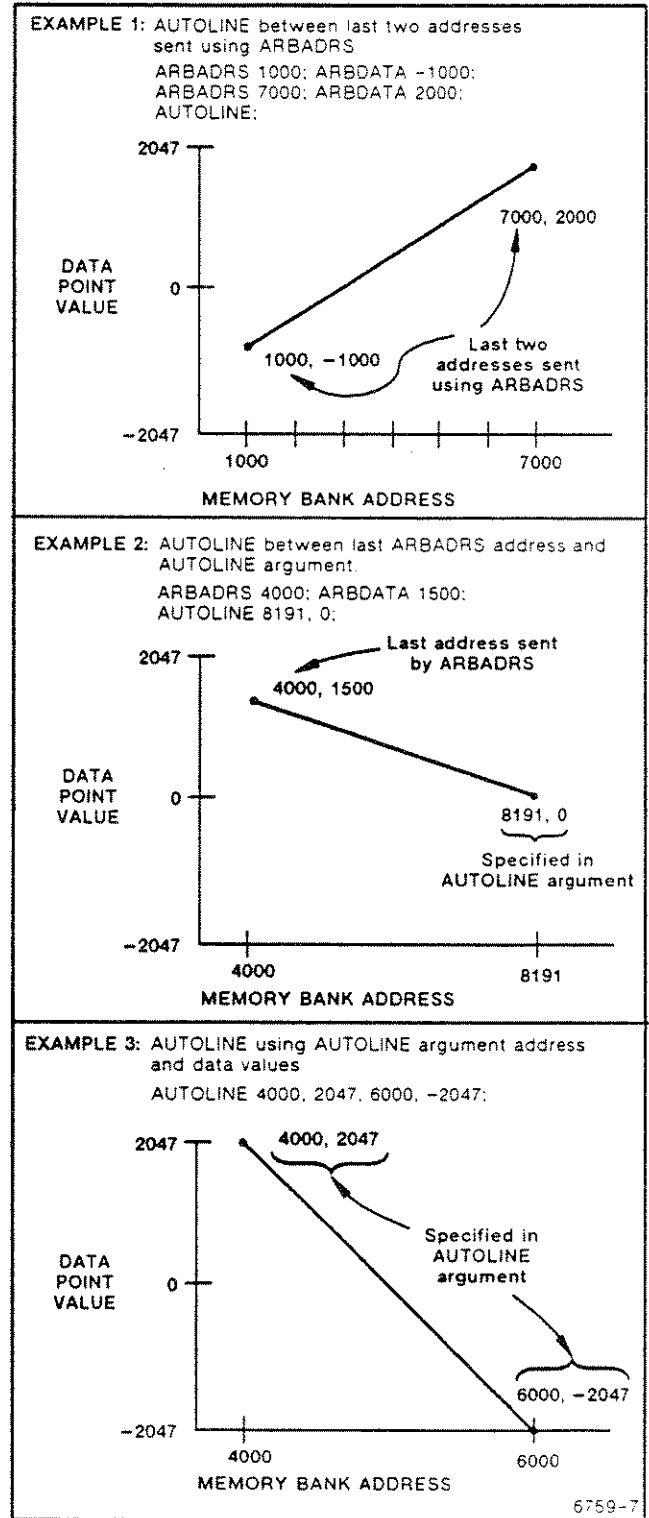


Fig. 3-3. AUTOLINE examples.

DC

Command Type:
Setting or query

Setting Syntax:
DC [<volts>]

Examples:
DC
DC 3.45
DC 5E-2
DC 699E-2

Query Syntax:
DC?

Query Response:
DC <num>;

Discussion:

This command selects a dc output. If the argument is omitted, the output level is the current level set for the DC parameter.

The response is returned in NR2 format.

DISPLAY

Command Type:
Setting or query

Setting Syntax:
DISPlay <parameter>

Examples:
DISP AMPL
DISPL FREQUENCY
DISPLA OFFSET
DISP NBURST
DISPLAY RATE

Query Syntax:
DISPlay?

Query Example:
DISPL?
DISPLA?
DISPLAY?

Query Response: (one of the following)

DISPL FREQ;
DISPL AMPL;
DISPL OFFS;
DISPL NBUR;
DISPL RATE;

Discussion:

The DISPL command changes the display window to show the parameter specified in the argument. The argument is limited to the following:

FREQuency
AMPLitude
OFFSet
NBURst
RATE

The query command returns the name of the parameter that is currently shown in the display window.

DT (Device Trigger)

Command Type:
Setting or query

Setting Syntax:
DT TRIG
DT GATE
DT SET
DT OFF

Query Syntax:
DT?

Query Response (one of the following):
DT TRIG;
DT GATE;
DT SET;
DT OFF;

Discussion:

This command controls the instrument's response to the Group Execute Trigger <GET> interface message.

When a <GET> interface message is received and the DT TRIG mode is set, the instrument produces one cycle of signal if it is in TRIG mode, or it produces a burst of cycles if it is in BURST mode.

If the trigger mode is set to GATE and <GET> is received, the output is turned on until <GET> is received again.

The SET argument causes the instrument to wait for a <GET> interface message before updating its settings.

The power-on setting is DT OFF; the instrument updates its settings without waiting for <GET>.

ERROR? or EVENT?

Command Type:
Query

Query Syntax:
ERRor?
EVENT?

Examples:
ERR?
ERROR?
EVENT?

Query Response: (depends on query sent)
ERR <num>;
EVENT <num>;

Discussion:

This query returns the error code for the last SRQ that was polled (with RQS ON), or it returns the error code for the oldest error in the error queue if RQS is OFF. Error code 0 is returned if the error queue is empty.

ERRM? (Error Message)

Command Type:

Query

Query Syntax:

ERRM?

Query Response:

ERRM <error#>, <error message>;

Discussion:

This query returns the error code and text that is displayed in the front panel window. The query returns error information matching the last SRQ that was polled with RQS ON, or the highest priority in the error queue if RQS was OFF. ERR 0 (Nothing to Report) is returned if there are no errors in the error queue.

FILTER

Command Type:

Setting or Query

Setting Syntax:

FILTER OFF|0|1|2|3|4

Query Syntax:

FILTER?

Examples:

FILTER 0
FILTER OFF
FILTER 1

Query Response: (one of the following)

FILTER 0;
FILTER 1;
FILTER 2;
FILTER 3;
FILTER 4;

Discussion:

This command selects one of four fixed, low-pass filters for application to an arbitrary waveform output. Argument *off* or *0* selects no filter.

- OFF No filter.
- 0 No filter.
- 1 Filter with 1 MHz cut-off frequency.
- 2 Filter with 100 kHz cut-off frequency.
- 3 Filter with 11 kHz cut-off frequency.
- 4 Filter with 1.3 kHz cut-off frequency.

FM (Frequency Modulation)

Command Type:
Setting or Query

Setting Syntax:
FM ON|OFF

Query Syntax:
FM?

Examples:
FM ON
FM OFF

Query Response:
FM ON;
FM OFF;

Discussion:

The *on* argument causes the instrument to use the signal applied to the VCO/FM IN connector to modulate the frequency of the main output signal. The polarity of the external input signal determines the direction in which the output will deviate in frequency: a positive-going input signal increases output signal frequency. The amplitude of the external input signal determines the percent of frequency change in the main output signal.

The *off* argument terminates frequency modulation.

The query returns the status of the FM command.

FREQUENCY

Command Type:
Setting or query

Setting Syntax:
FREQuency <frequency>[:<units>]

Examples:
FREQ 60
FREQ 11.99:MHZ
FREQ 11.99:kHz
FREQ 11E6
FREQ 60E2:HZ

Query Syntax:
FREQ?

Query Response:
FREQ <num>;

Discussion:

This command sets the output frequency to the value specified by the argument. The programmed value is rounded to the nearest increment of the frequency generator.

The default unit of measure is Hz; choices are HZ, KHZ, MHZ.

The power-on setting is FREQ 1:kHz.

Frequency can be specified to 3½ digits in normal mode; 4½ digits in synthesizer mode.

The query returns the current frequency setting in Hz.

FRQLCK (Frequency Lock)

Command Type:
Setting or query

Setting Syntax:
FRQLck ON
FRQLck OFF

Examples:
FRQL ON
FRQLCK OFF

Query Syntax:
FRQLck?

Query Response: (one of the following)
FRQL ON;
FRQL OFF;

Discussion:

With FRQL ON, internal circuitry and software improve the generator's frequency accuracy. For operation to frequency accuracy (listed under Electrical Specifications) FRQL must be *on*.

The power-on setting is FRQL ON.

FRQMARK (Frequency Marker)

Command Type:
Setting or query

Setting Syntax:
FRQMARK <freq>[:<units>]

Examples:
FRQMARK 60
FRQMARK 10:MHZ

Query Syntax:
FRQMARK?

Query Response:
FRQMARK <num>;

Discussion:

This command sets the marker frequency. When the marker frequency is encountered during a sweep, the marker output is enabled while that frequency is being output. Also, a marker is inserted in the output waveform. The marker appears as an intensified point on the waveshape.

Resolution is 3½ digits; default unit of measure is Hz.

Units of measure can be HZ, KHZ, or MHZ.

The power-on setting is 0. When the frequency is set to 0, the marker function is disabled.

The query returns the current setting of the frequency marker in Hz.

FRQSTART (Frequency Start)

Command Type:
Setting or query

Setting Syntax:
FRQSTART <freq>[:<units>]

Examples:
FRQSTART 59.99
FRQSTART 9.99:MHZ

Query Syntax:
FRQSTART?

Query Response:
FRQSTART <num>;

Discussion:

This command sets the frequency at which a sweep will begin. If the start frequency is greater than the stop frequency, a decrementing sweep is generated. Resolution is $3\frac{1}{2}$ digits; default unit of measure is Hz.

The power-on setting is FRQSTART 1 Hz.

Units of measure can be HZ, KHZ, or MHZ.

FRQSTOP (Frequency Stop)

Command Type:
Setting or query

Setting Syntax:
FRQSTOP <freq>[:<units>]

Examples:
FRQSTOP 4700
FRQSTOP 11:MHZ
FRQSTOP 1E6

Query Syntax:
FRQSTOP?

Query Response:
FRQSTOP <num>;

Discussion:

This command sets the frequency at which a sweep will end. If the start frequency is greater than the stop frequency, a decrementing sweep will occur.

The resolution is $3\frac{1}{2}$ digits; the default unit of measure is Hz. Units of measure can be HZ, KHZ, or MHZ.

The power-on setting is FRQSTOP 1200 Hz.

FUNCTION

Command Type:
Setting or query

Setting Syntax:
FUNCTION SINE
FUNCTION SQUARE
FUNCTION TRIANGLE
FUNCTION DC
FUNCTION ARBITRARY

Examples:
FUNC SINE
FUNCT SQUARE
FUNCTION DC
FUNCT TRIANG
FUNC ARB

Query Syntax:
FUNC?

Query Response (one of the following):
FUNC SINE;
FUNC SQUARE;
FUNC TRIANGLE;
FUNC DC;
FUNC ARBITRARY;

Discussion:

This command selects the type of waveform for output. FUNC SINE is the power-on setting.

When any of the standard waveform commands (SINE, SQU, TRIA) is sent, the level of the output is the current amplitude level. The DC level is set by the DC function. When FUNC ARB is sent, the amplitude level of the output is dependent upon the value of the data points stored for the arbitrary waveform. The amplitude of the arbitrary waveform output is scaled by the current amplitude setting. See Electrical Specification in Section 1 of this manual for more information on arbitrary waveform amplitude.

When ARBITRARY is selected, the arbitrary waveform must already be in waveform memory. The waveform information can be sent to the AFG 5101/5501 over the GPIB or the information can be input using front panel controls.

If FUNC ARB is received while an arbitrary waveform is executing, the waveform output is restarted at the START address after the values of the waveform are updated.

HELP?

Command Type:
Query

Query Syntax:
HELP?

Query Response:
<a string containing all AFG 5101/5501 commands>;

Discussion:

The HELP query command returns a string that is a list of all AFG 5101/5501 commands. The string consists of the following:

HELPAM, AMPL, ARB, ARBADRS, ARBCLR, ARBDATA, ARBHOLD, ARBLOAD, ARBPROG, ARBSEL, ARBSTART, ARBSTOP, AUTOLINE, DC, DISP, DT, ERR, ERRM, EVENT, FILTER, FM, FREQ, FRQL, FROMARK, FROSTART, FROSTOP, FUNC, HELP, ID, INIT, MODE, NBUR, OFFS, OPC, OUT, RATE, REC, RNLCK, RQS, SEND, SET, SINE, SQU, STOR, SWEEP, TEST, TRIA, TRIG, USER;

ID? (Identify)

Command Type:
Query

Query Syntax:
ID?

Query Response:
ID TEK/<model number>,<Tek Codes and Format version>,<firmware version>,<options, if installed>;

Query Response Example:
TEK/AFG5101,V81.1,F1.0,OPT02;

Discussion:

The ID? query command returns identification information about the instrument. If the instrument has no options, option information is omitted.

INIT (Initialize)

Command Type:
Setting

Setting Syntax:
INIT

Discussion:

The INIT command restores all front panel settings to the power-on states, except that the INCR SIZE setting, setup buffer data, and arbitrary waveform memory are not changed.

MODE

Command Type:
Setting or query

Setting Syntax:
MODE CONT
MODE TRIG
MODE BURST
MODE GATE
MODE SYNT

Examples:
MODE CONT
MODE TRIG
MODE BURST
MODE GATE
MODE SYNT

Query Syntax:
MODE?

Query Response (one of the following):
MODE CONT;
MODE TRIG;
MODE BURST;
MODE GATE;
MODE SYNT;

Discussion:

This command sets the trigger mode to the mode specified by the argument.

CONT Sets the AFG 5101/5501 to generate a continuous output signal. Trigger events are ignored. CONT is the power-on setting.

TRIG Sets the AFG 5101/5501 to the triggered output mode. One cycle of the output signal is generated for each trigger event. Trigger sources include an external trigger, internal trigger, manual trigger, or Group Execute Trigger <GET> over the GPIB. See also the TRIG and DT command descriptions.

BURST Sets the AFG 5101/5501 to the burst mode. When a trigger occurs, the instrument produces a burst of the programmed output signal; the number of cycles is determined by the N BURST parameter. All trigger sources apply.

GATE

Sets the AFG 5101/5501 to the gated mode. Output is generated while the MAN key is pressed or the trigger/gate input is enabled. If the gate signal on the trigger input is removed in the middle of a cycle, the cycle is completed.

SYNT

This mode is available only on an Option 02 instrument. It sets the AFG 5101/5501 to the synthesizer mode. If this mode is selected and the instrument does not have the option installed, an execution error is reported.

NBURST (Number of Burst Cycles)

Command Type:
Setting or query

Setting Syntax:
NBURST [<number of cycles>]

Examples:
NBURST
NBURST 10

Query Syntax:
NBURST?

Query Response:
NBURST <number of cycles>;

Discussion:

This command sets the number of cycles that will be output in burst mode. The power-on setting is 2 cycles; the range is 1 to 9999.

OFFSET

Command Type:
Setting or query

Setting Syntax:
OFFSet <offset voltage >

Examples:
OFFS 5
OFFSET 0.1

Query Syntax:
OFFS?

Query Response:
OFFS <voltage>;

Discussion:

This command sets the offset voltage of the output signal to the value specified by the argument. The argument is specified in volts. The absolute peak amplitude plus offset is limited to a maximum that is dependent on the signal amplitude range, as follows:

Amplitude Range	Peak Amplitude + Absolute Offset into 50 ohms	Resolution into 50 ohms
1V - 9.99V	4.99V	10mV
0.1V - 0.999V	0.499V	1mV
0.01V - 0.099V	0.049V	1mV

This formula describes the relationship between amplitude and offset:

$$\frac{\text{Dspld Amp.}}{2} + \text{Displayed Offset} = \frac{\text{Absolute peak amplitude + offset}}{\text{into 50 ohms, for range}}$$

The power-on setting is 0V (offset is disabled). An OFFS query returns the programmed offset value in volts.

OPC (Operation Complete)

Command Type:
Setting or query

Setting Syntax:
OPC ON
OPC OFF

Examples:
OPC ON
OPC OFF

Query Syntax:
OPC?

Query Response (one of the following):
OPC ON;
OPC OFF;

Discussion:

The OPC command enables or disables the operation complete service request. If enabled and RQS is ON, and MODE TRIG or MODE BURST is selected, the instrument asserts SRQ at completion of an arbitrary waveform sweep, or after one execution of arbitrary waveform memory. If RQS is *off*, the operation complete is queried, as an event.

The power-on setting is OPC OFF.

OUTPUT

Command Type:
Setting or query

Setting Syntax:
OUTput ON
OUTput OFF
OUTput FLOAT

Examples:
OUT ON
OUTP FLOAT
OUTPUT OFF

Query Syntax:
OUTput?

Query Response (one of the following):
OUT ON;
OUT OFF;
OUT FLOAT;

Discussion:

The OUTPUT command controls the AFG 5101/5501 output signal at the main OUTPUT connector.

ON Connects the AFG 5101/5501 output signal to the main OUTPUT connector.

FLOAT Disconnects the AFG 5101/5501 output signal from the main OUTPUT connector and terminates it into a high (floating) impedance.

OFF Disconnects the AFG 5101/5501 output signal from the main OUTPUT connector. Output is terminated into 50 ohms.

The power-on setting is OUTPUT OFF.

RATE

Command Type:
Setting or query

Setting Syntax:
RATE <num>[:<units>]

Examples:
RATE 999.9
RATE 100 NS
RATE 60 HZ

Query Syntax:
RATE?

Query Response:
RATE <NR3>:<units>;

Discussion:

This command sets the internal trigger interval. The power-on setting is 10 microseconds; the power-on units of measure is seconds. Units can be specified in seconds or Hz (front-panel SPCL function 210).

If the units of measure is set to Hz, all inputs and output are specified in Hz until the units are specified in seconds again.

The rate generator is used for internal trigger, sweep rate, and arbitrary waveform output rate.

RECALL

Command Type:
Operational

Syntax:
RECALL <num>

Examples:
REC 3
RECALL 8

Discussion:

This command changes the AFG 5101/5501 settings to those stored in the settings buffer specified in the argument, except for the following settings which are not stored in settings buffers and therefore remain unchanged:

- ARBADRS
- RQS
- OPC
- USER
- Increment Size
- SPCL function 220--Display intensity/backlight
- SPCL function 240--GPIB address
- SPCL function 241--GPIB message terminator
- SPCL function 250--Frequency MARKER status

The argument range is 0 to 99. Buffer 0 is a read-only buffer that contains the power-on settings. (All other settings buffers contain the power-on settings until they are changed by the user.)

RNGLCK (Range Lock)

Command Type:
Setting or query

Setting Syntax:
RNGLCK ON
RNGLCK OFF

Examples:
RNGLCK ON
RNGLCK OFF

Query Syntax:
RNGLCK?

Query Response (one of the following):
RNGLCK ON;
RNGLCK OFF;

Discussion:

The *on* argument turns on the range lock function. This function limits the generator's frequency output range to the limits of the frequency range currently in use (determined by *FREQ* setting).

When *RNGLCK* is set *on*, the frequency change is locked and the output frequency is set to its lowest value. Changing the frequency parameter will not affect the range or output frequency. When *RNGLCK* is set *on*, the maximum allowable sweep range is allowed using an external sweep.

The power-on setting is *RNGLCK OFF*.

RQS (Request for Service)

Command Type:
Setting or query

Setting Syntax:
RQS ON
RQS OFF

Examples:
RQS ON
RQS OFF

Query Syntax:
RQS?

Query Response (one of the following):
RQS ON;
RQS OFF;

Discussion:

The *RQS* command controls the AFG 5101/5501 service request operation. Valid arguments are:

ON Allows the AFG 5101/5501 to generate an *SRQ* to report an event or error.

OFF Prevents the AFG 5101/5501 from generating an *SRQ* to report an event or error.

An *RQS* query returns the current request-for-service status. The *ERR* query can be used while *RQS* is off to determine if any *SRQ* conditions have occurred. See *Status and Error Reporting* in this section for more information.

The power-on setting is *RQS ON*.

SEND**Command Type:**

Query

Query Syntax:

SEND? <bufnum>[, <bufnum>]. . .
SEND? ALL

Examples:

SEND? 3,5
SEND? 80
SEND? ALL

Query Response:

STOR <bufnum>: <binblk> [, <bufnum>: <binblk>]...;
or
STOR ALL: <binblk> ... <binblk>; (99 settings)

Discussion:

In response to this command, the AFG 5101/5501 transmits over the GPIB, the contents of the stored settings buffer(s) identified in the argument. Argument range is 1 to 99. The settings data is sent in binary block format.

SET?**Command Type:**

Query

Query Syntax:

SET?

Query Response Example:

FREQ 1.0E+3; AMPL 5.0; OFFS 0; DC 0; RATE
10.0E-6:S; NBUR 2; FRQSTART 1.0; FRQSTOP 1.2E+3;
FROMARK 0; SWEEP OFF; ARBSEL 1; ARBADRS 0; ARB-
START 0; ARBSTOP 8191; FILTER OFF; FUNC SINE;
MODE CONT; TRIG MANUAL; AM OFF; FM OFF; OUT
OFF; FRQL ON; RNGLCK OFF; ARBHOLD OFF; ARB-
PROG OFF; DT OFF; RQS ON; USER OFF; OPC
OFF; DISP FREQUENCY;

Discussion:

This command returns the status of all instrument settings that can be set and that respond to a query command with the following exceptions:

stored front panel settings
arbitrary waveforms

STORE

Command Type:

Operational

Syntax:

STORE <num>[:<binblk>[,<num>:<binblk>]]...
 STORE ALL:<binblk>...<binblk>

Discussion:

The current settings of the instrument are saved in the settings buffer specified by the argument (<num>). If the optional <binblk> argument is included, the data stored in the specified settings buffer is the data in the argument; if the <binblk> argument is omitted, the data stored in the settings buffer is the current front panel settings data. Multiple arguments are allowed if connected by a comma.

The following settings are not stored by the STORE command:

- ARBADRS
- RQS
- OPC
- USER
- Increment Size
- SPCL function 220--Display intensity/backlight
- SPCL function 240--GPIB address
- SPCL function 241--GPIB message terminator
- SPCL function 250--Frequency MARKER status

The STORE ALL command stores each binary block settings packet received over the GPIB in a settings buffer. The first binary block packet is stored in settings buffer 1, the second packet in settings buffer 2, and so on to 99. All buffers must be present.

If a binary block packet is longer or shorter than required, the instrument reports an execution error. If a binary block packet has a bad checksum byte, the instrument reports an execution error. If one packet in the argument is in error, then an error is generated and that packet and all succeeding packets are discarded; all packets up to the discarded packet are stored. The error number returned reflects the number of the bad packet.

Settings buffer 0 is a read-only buffer that contains the power-on settings. This buffer cannot be stored into.

SWEEP

Command Type:

Operational or query

Syntax:

SWEEP LIN
 SWEEP LOG
 SWEEP ARB
 SWEEP OFF

Query Syntax:

SWEEP?

Query Response (one of the following):

SWEEP LIN;
 SWEEP LOG;
 SWEEP ARB;
 SWEEP OFF;

Discussion:

This command sets the sweep to the shape specified by the argument.

LIN Sets the sweep shape to a linear sweep.

LOG Sets the sweep shape to a logarithmic sweep.

ARB Sets the sweep shape to the arbitrary waveform in the currently selected arbitrary waveform buffer. Use ARBSTART and ARBSTOP to define the section of arbitrary memory to be used for the sweep function.

OFF Disables the sweep operation.

The power-on setting is SWEEP OFF.

The sweep is generated by using the arbitrary waveform generator and inserting a 1000-point ramp. The value of the RATE parameter will determine the number of sweeps per second.

TEST?

Command Type:
Query

Query Syntax:
TEST?

Query Response:
TEST <num>;

Discussion:

This command causes the instrument to execute internal checkout routines. A code in the response indicates the test results. If the instrument successfully passes the test, the code number is 0; a failure is defined by the error code number returned, as follows:

- 0 - No error detected.
- 1 - An error was detected.

During the test, output is turned off and the GPIB port remains active; output is resumed following test completion.

TRIG

Command Type:
Setting or query

Setting Syntax:
TRIG INT
TRIG EXT
TRIG MANual

Examples:
TRIG INT
TRIG EXT
TRIG MAN

Query Syntax:
TRIG?

Query Response (one of the following):
TRIG IN;
TRIG EXT;
TRIG MAN;

Discussion:

This command selects the trigger source as specified by the argument.

INT Selects an internal trigger. This trigger can not be used in arbitrary and sweep modes.

EXT Selects an external trigger. The source is the signal applied to the TRIG IN connector.

MAN Selects the manual trigger source. Pressing the MAN button generates a trigger.

The query returns the current trigger source selection.

The power-on setting is TRIG MAN.

USEREQ

Command Type:

Setting or query

Setting Syntax:

USEReq ON

USEReq OFF

Examples:

USEREQ ON

USER OFF

Query Syntax:

USER?

Query Response (one of the following):

USER ON;

USER OFF;

Discussion:

The USER command enables the AFG 5101/5501 to assert SRQ when the user presses the front panel INST ID key. This provides a means of communication between the user and the controller through the AFG 5101/5501 for coordination of AFG 5101/5501 operations. Valid arguments are:

ON If RQS is ON, the AFG 5101/5501 asserts SRQ when the user presses the INST ID key. SRQ remains asserted until the status is read by a serial poll, or until a Device Clear (DCL) is performed by the controller. The USER SRQ is indicated by a status byte of 67 or 83, and an error query response of 403. If RQS is OFF, the event can be detected via the ERR query.

OFF Disables the USEREQ function. SRQ assertion is disabled and no errors will be reported.

A USER query returns the current status. The power-on setting is USER OFF.

MESSAGES AND COMMUNICATION PROTOCOL

Command Separator

A message consists of one command or a series of commands, followed by a message terminator. Commands in multiple command messages must be separated by semicolons. A semicolon at the end of a message is optional. For example, each line below is a message.

```
INIT
TEST?;INIT;RQS ON;USER OFF;ID?;SET?
TEST?;
```

Address and Message Terminator Selection

Messages may be terminated with EOI or the ASCII line feed (LF) character. Some controllers assert EOI concurrently with the last data byte; others use only the LF character as a terminator. The instrument can be set to accept either terminator. With EOI only selected as the terminator, the instrument interprets a data byte received with EOI asserted, as the end of the input message; it also asserts EOI concurrently with the last byte of the output messages. With the LF/EOI setting, the instrument interprets the LF character without EOI asserted (or any data byte received with EOI asserted) as the end of an input message; it transmits carriage return (CR) followed by line feed (the LF with EOI asserted) to terminate output messages.

NOTE

Do not use LF mode when transmitting or receiving Binary Block data. See ARBDATA, SEND?, STOR.

The AFG 5101/5501 is shipped from the factory with a GPIB address of 7; the terminator is LF with EOI.

Both the GPIB primary address and the message terminator are selected using front panel keys. These selections are stored in non-volatile RAM. The following steps outline the selection process:

1. Press the INST ID key. The current GPIB address and terminator are indicated in the display window (while the key is pressed).
2. To change the GPIB address, press the SPCL

key; press keypad numbers 240; press ENTER.

Press the keypad numbers for the new GPIB address; press ENTER. The new address should be shown in the display window.

The legal values are 0 to 31. Address 31 disconnects the AFG 5101/5501 from bus communication.

3. To change the terminator selection, press the SPCL key; press keypad numbers 241; press ENTER; press the INCREMENT up- or down-arrow to change the terminator selection. The new terminator selection should be indicated in the display window.

Formatting a Message

Commands sent to TM 5000 instruments must have the proper format (syntax) to be understood; however, this format is flexible in that many variations are acceptable. The following describes the format and the acceptable variations.

The instruments expect all commands to be encoded in ASCII, with either upper or lower case ASCII characters acceptable. All data output is in upper case (see Fig. 3-1). As previously discussed, a command consists of a header, followed if necessary, by arguments. A command with arguments must have a header delimiter, which is the space character (SP) between the header and the argument. The space character (SP), carriage return (CR), and line feed (LF) are shown as subscript in the following examples.

RQS_{SP}ON

If extra formatting characters SP, CR, and LF (the LF cannot be used for format in the LF/EOI terminator mode) are added between the header delimiter and the argument, those characters are ignored by the instrument.

Example 1: RQS_{SP}ON;

Example 2: RQS_{SP}SP_{SP}ON;

Example 3: RQS_{SP}CR_{LF}
SP_{SP}ON

In general, these formatting characters are ignored after any delimiter and at the beginning and end of a message. For example:

```
SPRQSSPONCR LF
SPUSERSPOFF
```

In the command list, some headers and arguments are listed in two forms, a full-length version and an abbreviated version. The instrument accepts any header or argument containing at least the characters listed in the short form; any characters added to the abbreviated version must be those given in the full-length version. For documentation of programs, the user may add alpha characters to the full-length version. Alpha characters may also be added to a query header, provided the question mark is at the end.

```
USER?
USERE?
USEREQ?
USEREQUEST?
```

Multiple arguments are separated by a comma; however, the instrument will also accept a space or spaces as a delimiter.

```
2,3
2SP3
2,sp3
```

NOTE

In the last example, the space is treated as a format character because it follows the comma (the argument delimiter).

Number Formats

The instrument accepts the following kinds of numbers for any of the numeric arguments.

NR1 Signed or unsigned integers (including +0 and -0). Unsigned integers are interpreted as positive.

Examples: +1, 2, -1, -10.

NR2 Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted as positive.

Examples: -3.2, +5.0, 1.2

NR3 Floating point numbers expressed in scientific notation.

Examples: +1.0E-2, 1.0E2, 1.E-2, 0.01E+0

Link arguments can be used in place of scientific notation.

Examples: +10:MHZ, -.25:V, 2:KHZ.

Rounding of Numeric Arguments

The instrument rounds numeric arguments to the nearest unit of resolution and then checks for out-of-range conditions.

Message Protocol

Upon receipt by the instrument, a message is stored in the Input Buffer, then processed, and executed. Processing a message consists of decoding commands, detecting delimiters, and checking syntax. For *setting commands*, the instrument then stores the indicated changes in the Pending Settings Buffer. If an error is detected during processing, the instrument asserts SRQ, ignores the remainder of the message, and resets the Pending Settings Buffer. Resetting the Pending Settings Buffer avoids undesirable states that could occur if some *setting commands* are executed while others in the same message are not.

Executing a message consists of performing the actions specified by its command(s). For *setting commands*, this involves updating the instrument settings and recording these updates in the Current Settings Buffer. The *setting commands* are executed in groups--that is, a series of *setting commands* is processed and recorded in the Pending Settings Buffer before execution takes place. This allows the user to specify a new instrument state without having to consider whether a particular sequence would be valid. Normally, execution of the settings occurs when the instrument processes the message terminator, *query-output command*, or an *operational command* in a message. The normal execution of settings is modified by the Device Trigger (DT) setting command.

When the instrument processes a *query-output command* in a message, it executes any preceding *setting commands* to update the state of the instrument. It then executes the *query-output command* by retrieving the appropriate information and putting it in the Output Buffer. Processing and execution then continue for the remainder of the message. The data are sent to the controller when the instrument is made a talker.

When the instrument processes an *operational command* in a message, it executes any preceding *setting commands* before executing the *operational command*.

Multiple Messages

The Input Buffer has finite capacity and thus a single message may be long enough to fill it. In this case, a portion of the message is processed before the instrument accepts additional input. During command processing, the instrument holds off additional data (by asserting NRFD) until space is available in the buffer. When space is available, the instrument can accept a second message before the first has been processed. However, it holds off additional messages with NRFD until it completes processing the first.

After the instrument executes a *query-output command* in a message, it holds the response in its Output Buffer until the controller makes the instrument a talker. If the instrument receives a new message before all of the output from the previous message is read, it clears the Output Buffer before executing the new message. This prevents the controller from getting unwanted data from old messages.

One other situation may cause the instrument to delete output. The execution of a long message might cause both the Input and Output Buffers to become full. When this occurs, the instrument cannot finish executing the message because it is waiting for the controller to read the data it has generated; but the controller cannot read the data because it is waiting to finish sending its message. Because the instrument Input Buffer is full and it is holding off the rest of the controller's message with NRFD, the system is hung up with the controller and instrument waiting for each other. When the instrument detects this condition, it generates an error, asserts SRQ and

deletes the data in the Output Buffer. This action allows the controller to transmit the rest of the message, and informs the controller that the message was executed and that the output was deleted.

A TM 5000 instrument can be made a talker without having received a message that specifies the output. In this case, an acquisition instrument (a counter or a multimeter) returns a measurement if one is ready. If no measurement is ready, it returns a single byte message with all bits equal to 1 (with message terminator). Non-acquisition TM 5000 instruments will return only this message.

Instrument Response to IEEE-488 Interface Messages

Interface messages and the effects of those messages on the instrument interface functions are defined in IEEE Standard 488-1978. Abbreviations from the standard are used in this discussion, which describes the effects of interface messages on instrument operation. Where appropriate, the GPIB code is listed, in decimal.

UNL—Unlisten (63 with ATN))

UNT—Untalk (95 with ATN)

When the UNL command is received, the instrument listener function goes to its idle state (unaddressed). In the idle state, the instrument will not accept instrument commands from the IEEE-488 bus.

The talker function goes to its idle state when the instrument receives the UNT command. In this state, the instrument cannot supply output data via the bus.

The addressed indicator is off when both the talker and listener functions are idle. If the instrument is either talk-addressed or listen-addressed, the indicator is on.

IFC—Interface Clear (Bus pin 9)

This uniline message has the same effect as both the UNT and UNL messages. The front panel ADDRESSED indicator is off.

DCL—Device Clear (20 with ATN)

The Device Clear message reinitializes communication between the instrument and controller. In response to DCL, the instrument clears any input and output messages and any unexecuted settings in the Pending Settings Buffer. Also cleared are any errors or events waiting to be reported, except the power-on event. If the SRQ line is asserted for any reason other than power-on when DCL is received, SRQ is unasserted.

SDC—Selected Device Clear (4 with ATN)

This message performs the same function as DCL; however, only instruments that are listen-addressed respond to SDC.

GET—Group Execute Trigger (8 with ATN)

The instrument responds to <GET> only if it is listen-addressed and the instrument device trigger function has been enabled by the Device Trigger command (DT). The <GET> message is ignored and an SRQ generated if the DT function is disabled (DT OFF), the instrument is in the local state, or if a message is being processed when <GET> is received.

SPE—Serial Poll Enable (24 with ATN)

The SPE message enables the instrument to supply output serial poll status bytes when it is talk addressed.

SPD—Serial Poll Disable (25 with ATN)

The SPD message switches the instrument back to its normal operation of sending the data from the Output Buffer.

MLA—My Listen Address (Address + 32)

MTA—My Talk Address (Address + 64)

The primary listen and talk addresses are established by the instrument IEEE-488 bus address (set by front-panel key sequence). The current setting of the bus address ID displayed on the front panel when the INST ID key is pressed. When the instrument is addressed to talk or listen, the front panel ADDRESSED indicator is lighted.

LLO—Local Lockout (17 with ATN)

In response to LLO, the instrument changes to a lockout state--from LOCS to LWLS or from REMS to RWLS.

REN—Remote Enable (GPIO pin 17)

If REN is true, the instrument may change to a remote state (from LOCS to REMS if the internal message return-to-local (rtl) is false, or from LWLS to RWLS) when its listen address is received. REN false causes a transition from any state to LOCS; the instrument stays in LOCS as long as REN is false.

A REN transition may occur after message processing has begun. In this case, execution of the message being processed is not affected by a transition.

GTL—Go To Local (1 with ATN)

Only instruments that are listen-addressed respond to GTL by changing to a local state. Remote-to-local transitions caused by GTL do not affect the execution of the message being processed when GTL was received.

Remote-Local Operation

The preceding discussion of interface messages describes the state transitions caused by GTL and REN. Most front panel controls cause a transition from REMS to LOCS by asserting a message called return-to-local (rtl). This transition may occur during message execution; but, in contrast to GTL and REN transitions, a transition initiated by rtl does affect message execution. In this case, the instrument generates an error if there are any unexecuted *setting* or *operational commands*. Front panel controls that change only the display (such as INST ID) do not affect the remote-local states--only front panel controls that change settings assert rtl. The rtl message remains asserted while multiple keystroke settings are entered, and it is unasserted after the execution of the settings. Since rtl prevents transition to REMS, the instrument unasserts rtl if a multiple key sequence is not completed in a reasonable length of time (approximately 5 to 10 seconds).

The instrument maintains a record of its settings in the Current Settings Buffer and new settings from the front panel or the controller update these recorded settings. In addition, the front panel is updated to reflect setting changes caused by commands. Instrument settings are unaffected by transitions among the four remote-local states. The REMOTE indicator is lighted when the instrument is in REMS or RWLS.

Local State (LOCS)

In LOCS, instrument settings are controlled by the operator via front panel keys. When in LOCS, only bus commands that do not change instrument settings are executed (*query-output commands*.) All other bus commands (*setting and operational*) generate an error since those functions are under front panel control.

Local Without Lockout State (LWLS)

The instrument operates the same as it does in LOCS, except that rtl will not inhibit a transition to remote.

Remote State (REMS)

In this state, the instrument executes all instrument commands. For commands having associated front panel indicators, the front panel is updated when the commands are executed.

Remote With Lockout State (RWLS)

Instrument operation is similar to REMS operation except that the rtl message is ignored. (The front panel is locked out.)

Status and Error Reporting

Through the Service Request function (defined in the IEEE-488 Standard), the instrument may alert the controller that it requires service. This service request is also a means of indicating that an event (a change in status or an error) has occurred. To service a request, the controller performs a Serial Poll. In response, the instrument returns a Status Byte (STB), which indicates

whether it was requesting service or not. The STB can also provide a limited amount of information about the request. The format of the information encoded in the STB is given in Fig. 3-4. Note that, when data bit 8 is set, the STB conveys Device Status information, which is contained in bits 1 through 4.

Because the STB conveys limited information about an event, the events are divided into classes; the Status Byte reports the class. The classes of events are defined as follows:

Command Error--Indicates that the instrument has received a command which it cannot understand or implement under any circumstances. The command will not affect the state of the instrument.

Execution Error--Indicates that the instrument has received a command that is cannot execute. (This is caused by out-of-range arguments or settings that conflict.)

Internal Error--Indicates that the instrument has detected a hardware condition or firmware problem that prevents operation.

System Events--Events that are common to instruments in a system (e.g., Power On, User Request, etc.).

Execution Warning--Indicates that the instrument is operating, but that the user should be aware of potential problems.

Internal Warning--Indicates that the instrument has detected a problem (e.g., out of calibration). (The instrument remains operational, but the problem should be corrected.)

Device Status--Device dependent events. The instrument can provide additional information about many of the events, particularly the errors reported in the Status Byte. After determining that the instrument requested service (by examining the STB), the controller may request the additional information by sending an ERR query (ERR?). In response, the instrument returns a code that defines the event. These codes are described in Table 3-1. Note that some errors are also shown in the front panel display window. (Refer to Table 3-2 for a list of errors that are reported only on the front panel display.)

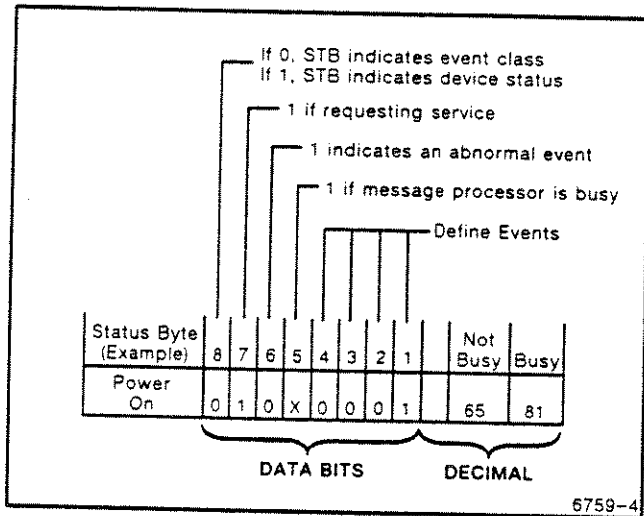


Fig. 3-4. Definition of STB bits.

Table 3-1
ERROR QUERY AND STATUS INFORMATION
(Bus Reportable)

Description	Error Query Response	Serial Poll Response ^a
Abnormal Events		
Command Errors (100 Series)		
Command header error	101	97
Header delimiter error	102	97
Command argument error	103	97
Argument delimiter error	104	97
Missing argument	106	97
Invalid message unit delimiter	107	97
Checksum error	108	97
Bytecount error	109	97
Execution Errors (200 Series)		
Command not executable in local	201	98
Setting lost due to rtl	202	98
Output buffer full	203	98
Settings conflict	204 ^b	98
Out of range	205 ^b	98
Group Execute Trigger ignored	206	98
ARB I-TRIG conflict	207 ^b	98
SWEEP I-TRIG conflict	208 ^b	98
AMPL-OFFSET conflict	250 ^b	98
DATA out of range	251 ^b	98

Table 3-1 (Cont.)

Description	Error Query Response	Serial Poll Response ^a
Execution Errors (200 Series) (Cont.)		
INCREMENT out of range	253 ^b	98
Bad settings buffer	255 ^b	98
ADDR out of range	256 ^b	98
SWEEP operation error	261 ^b	98
SYNT not installed	262 ^b	98
NBURST out of range	270 ^b	98
RATE out of range	271 ^b	98
MARK out of range	272 ^b	98
FREQ out of range	273 ^b	98
AMPL out of range	274 ^b	98
OFST out of range	275 ^b	98
START out of range	276 ^b	98
STOP out of range	277 ^b	98
ARBCLR start/stop is out of range	278	98
DC out of range	280 ^b	98
SYNT illegal parameter	290 ^b	98
Store binary block error	801-899	98
Internal Errors (300 Series)		
Save RAM failure	340 ^b	99
SYNT out of lock	350	99
Normal Events		
System Events (400 Series)		
Power on	401	65
Operation complete	402	66
User request	403	67
Internal Warnings (600 Series)		
Low battery	650 ^b	102
Output overload	660 ^b	102

^aIf the instrument is busy, it returns a decimal number 16 higher than the number listed.

^bThis error is also displayed in the front panel display window.

Table 3-2
FRONT PANEL ERROR CODES
 (Non-Bus Reportable)

Code	Error Description
010	Incorrect syntax.
011	Increment step error.
012	Increment limit.
013	Decrement limit.
014	INCR/DECR error.
015	SPCL not exist.
016	Mode conflict.
204	Setting conflict.
205	Out of range.
207	ARB Internal-Trig conflict.
208	SWEEP Internal-Trig conflict.
250	AMPL OFFSET conflict.
251	DATA out of range.
253	INCREMENT out of range.
255	Bad settings buffer.
256	ADRS out of range.
261	SWEEP operation error.
262	Synthesizer not installed (Option 02).
270	N BURST out of range.
271	RATE out of range.
272	MARKER out of range.
273	FREQ out of range.
274	AMPL out of range.
275	OFFSET out of range.
276	START out of range.
277	STOP out of range.
280	DC out of range.
290	SYNThesizer illegal parameter.
340	Save RAM failure.
650	Low battery.
660	Output overload.

If there is more than one event to be reported, the instrument continues to assert SRQ until it reports all events. (SRQ "stacking" consists of reporting only the latest event of each priority level.) Each event is automatically cleared when it is reported via Serial Poll. The Device Clear (DCL) interface message may be used to clear all events except Power-On.

Commands are provided to control the reporting of some individual events and to disable all service requests. For example, the User Request command (USER) provides individual control over the reporting of the user request event that occurs when the front panel INST ID key is pressed. The Request for Service command (RQS) controls whether the instrument reports any events with SRQ.

RQS OFF inhibits all SRQ's. When RQS is OFF, the ERR query allows the controller to find out about events without first performing a Serial Poll. With RQS OFF, the controller may send the ERR query at any time and the instrument will return an event waiting to be reported. The controller can clear all events by sending the ERR query until a ERR 0 code is returned, or clear all events except Power-On through the DCL interface message.

With RQS OFF, the controller may perform a Serial Poll, but the Status Byte contains only Device Dependent Status information. With RQS ON, the STB contains the class of the event and a subsequent error query returns additional information about the previous event reported in the STB.

Sending Interface Control Messages

Interface messages and the effects of those messages on the AFG 5101/5501 interface functions are defined in IEEE Standard 488-1978. Abbreviations from that standard are used in this description of the effects on instrument operation.

Bus interface control messages are sent as low-level commands through the use of WBYTE controller commands. Higher level commands are also available for the user. For the following commands, A is 32 plus the instrument's GPIB address, B is 64 plus the address, and C is the instrument's GPIB address.

Listen (MLA)	wbyte atn(A)
Unlisten (UNL)	wbyte atn(unl)
Talk (MTA)	wbyte atn(B)
Untalk	wbyte atn(unt)
Untalk-Unlisten	wbyte atn(unl,unt)
Device Clear (DCL)	wbyte dcl
Selective Device Clear(SDC)	wbyte sdc(C)
Go To Local (GTL)	wbyte gtl(C)
Remote with Lockout (RWLS)	wbyte atn(A), llo,atn(unl)
Local Lockout (LLO)	wbyte llo
Group Execute Trigger (GET)	wbyte get(C)

These commands are for the Tektronix 4041 controller and may be representative for some other controllers.

Power-On Sequences and Default Settings

Each time power is applied to the AFG 5101/5501, the internal microprocessor performs a self-test diagnostic routine to check the instrument RAM and ROM functionality. If no RAM or ROM error is found, the microprocessor performs further routines that check the functionality of other instrument hardware.

If a RAM or ROM error is found, an error code will be displayed on the front panel readout. In this error state, the AFG 5101/5501 will not respond to input from the front panel or the IEEE-488 bus interface. Internal errors detected after the RAM and ROM tests have been completed successfully will be reported at the front panel and over the IEEE-488 bus. In this error state, the AFG 5101/5501 will respond to input and will attempt to operate despite the error. An error code may be removed from the display by pressing the front panel INST ID button, by starting a numeric entry, by incrementing the selected parameter, by pressing the CLEAR key, or by a transition into the remote state (REMS).

When the self-test has been completed, the AFG 5101/5501 enters the local state (LOCS) and assumes the following default settings:

Table 3-3
POWER-ON DEFAULT SETTINGS

Key/Function	Setting
AMPL	5 V
Amplitude Modulation	off
Arbitrary ADRS	0000
Arbitrary ADRS Increment (SPCL 310)	on
Arbitrary Bank Select	1
Arbitrary Filter	off
Arbitrary PROG Mode	off
Arbitrary START	0000
Arbitrary STOP	8191
DC	0 V
Device Trigger ^a	off
FREQ	1 kHz
Frequency Lock (SPCL 230)	on
Frequency Modulation	off
Frequency marker	off
Function	SINE
MODE	CONT
N BURST	2
OFFSET	0 V (off)
Operation Complete ^a	off
OUTPUT	off
RATE	10 microsec.
RATE units	time
Range Lock (SPCL 260)	off
Request Service (RQS) ^a	on
SWEEP	off
Sweep MARKER Frequency	0 Hz (off)
Sweep START Frequency	1 Hz
Sweep STOP Frequency	1200 Hz
TRIG	MAN
User Service Request ^a	off

^aSettings used only when AFG 5101/5501 is under program control.

The SRQ line on the GPIB is also asserted unless the GPIB address is set to 31 (ignore GPIB commands). If the instrument is polled by the controller, the status byte returned will be 0100 0001 (65 decimal; power-on SRQ).

ASCII & GPIB CODE CHART

BITS		B7 B6 B5		B4 B3 B2 B1		B7 B6 B5		B4 B3 B2 B1		B7 B6 B5		B4 B3 B2 B1		B7 B6 B5		B4 B3 B2 B1	
CONTROL				NUMBERS SYMBOLS				UPPER CASE				LOWER CASE					
0	0	0	0	20	0	16	0	100	0	120	16	140	0	160	16		
				NUL		DLE		SP	0	@	P	'		p			
1	0	1	0	21	10	16	20	40	32	30	48	40	64	50	80	60	96
				SOH	DC1		!	1		A	Q	a		q			
1	1	1	1	22	11	17	21	41	33	31	49	41	65	51	81	61	97
				STX	DC2		"	2		B	R	b		r			
2	0	1	0	23	12	18	22	42	34	32	50	42	66	52	82	62	98
				ETX	DC3		#	3		C	S	c		s			
2	1	1	0	24	13	19	23	43	35	33	51	43	67	53	83	63	99
				EOT	DC4		\$	4		D	T	d		t			
3	0	1	0	25	14	20	24	44	36	34	52	44	68	54	84	64	100
				ENQ	NAK		%	5		E	U	e		u			
3	1	1	0	26	15	21	25	45	37	35	53	45	69	55	85	65	101
				ACK	SYN		&	6		F	V	f		v			
4	0	1	0	27	16	22	26	46	38	36	54	46	70	56	86	66	102
				BEL	ETB		'	7		G	W	g		w			
4	1	1	0	28	17	23	27	47	39	37	55	47	71	57	87	67	103
				BS	CAN		(8		H	X	h		x			
5	0	1	0	29	18	24	28	48	40	38	56	48	72	58	88	68	104
				HT	EM)	9		I	Y	i		y			
5	1	1	0	30	19	25	29	49	41	39	57	49	73	59	89	69	105
				LF	SUB		*	:		J	Z	j		z			
6	0	1	0	31	20	26	30	50	42	40	58	50	74	60	90	70	106
				VT	ESC		+	;		K	[k		{			
6	1	1	0	32	21	27	31	51	43	41	59	51	75	61	91	71	107
				FF	FS		,	<		L	\	l		 			
7	0	1	0	33	22	28	32	52	44	42	60	52	76	62	92	72	108
				CR	GS		-	=		M]	m		}			
7	1	1	0	34	23	29	33	53	45	43	61	53	77	63	93	73	109
				SO	RS		.	>		N	^	n		~			
8	0	1	0	35	24	30	34	54	46	44	62	54	78	64	94	74	110
				SI	US		/	?		O	_	o		DEL (RUBOUT)			
8	1	1	0	36	25	31	35	55	47	45	63	55	79	65	95	75	111

KEY

octal	25	PPU	GPIB code
	NAK		ASCII character
hex	15	21	decimal

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COMMITTED TO EXCELLENCE

REF ANSI STD X3. 4-1977
IEEE STD 488-1978
ISO STD 646-1973

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Fig. 3-5. ASCII and IEEE (GPIB) Code Chart.

Talker Listener Programs

The following sample programs allow a user to send any of the commands listed in the Functional Command List and to receive the data generated.

Talker Listener Program For Tektronix 4041 Controllers

```
100 Rem AFG 5101/5501 TALKER/LISTENER
110 Rem AFG PRIMARY ADDRESS 7
120   Init all
130   On srq then gosub srqhdl
140   Enable srq
150   Dim respons$ to 300
160   Input prompt "ENTER MESSAGE(S): ":message$
170   Print #7:message$
180   Rem input from device
190   Input #7:respons$
200   Print "RESPONSE: ";respons$
210   Goto 160
220   Rem SERIAL POOL ROUTINE
230 Srqhdl:   poll stb,pri
240   Resume
250   End
```

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Talker Listener Program For Tektronix PEP 301 Controllers

```

'*****
' ***** AFG 5101/5501 TALKER/LISTENER PROGRAM *****
' *****

' THIS PROGRAM REQUIRES THAT THE AFG 5101/5501 ADDRESS TO BE SET
' TO THE FACTORY DEFAULT OF 7.
COMMON SHARED IBSTA%, IBERR%, IBCNT%
ID$ = "TEKDEV1"
CALL IBFIND(ID$, BD%)
AFG% = 7
CALL IBPAD(BD%, AFG%)
ID$ = "GPIB0"
CALL IBFIND(ID$, GP%)
REMOTE% = 1
CALL IBSRE(GP%, REMOTE%)
CLS
DOOVER:
PRINT "*****"
PRINT "***** AFG 5101/5501 TALKER LISTENER PROGRAM *****"
PRINT "*****"
PRINT "RETURN TO EXIT: "
INPUT "ENTER MESSAGE(S)"; WRT$
CALL IBWRT(BD%, WRT$)
GOSUB CHECKGPIB
IF WRT$ = "" THEN GOTO TERMINATE
' ***** INPUT FROM DEVICE *****
REPLY$ = SPACES(300)
CALL IBRD(BD%, REPLY$)
GOSUB CHECKGPIB
GOSUB CHECKAFG
PRINT : PRINT "INSTRUMENT REPLY "; REPLY$
PRINT : PRINT "Returned status byte:"; SPR%,
PRINT : PRINT ERRM$
GOTO DOOVER
' ***** ERROR ROUTINES *****
CHECKAFG:
ERRM$ = SPACES(50)
CALL IBRSP(BD%, SPR%)
CALL IBWRT(BD%, "ERRM?")
CALL IBRD(BD%, ERRM$)
RETURN

CHECKGPIB:
IF IBSTA% >= 0 AND BD% >= 0 AND IBSTA% < &H4000 AND IBERR% <> 6 THEN RETURN
'no error to report
IF BD% < 0 THEN PRINT "device not installed - use IBCONF then reboot"
IF IBSTA% > 0 AND IBSTA% >= &H4000 THEN PRINT "timeout"
IF IBERR% = 6 THEN PRINT "timeout"
PRINT "gpib error "; IBERR%
IF IBERR% = 0 THEN PRINT "DOS error device not installed"
IF IBERR% = 1 THEN PRINT "function requires GPIB-PC to be CIC"
IF IBERR% = 2 THEN PRINT "no listener on write function"
IF IBERR% = 3 THEN PRINT "GPIB-PC not addressed correctly"
IF IBERR% = 4 THEN PRINT "invalid argument to function call"
IF IBERR% = 5 THEN PRINT "GPIB-PC not system controller as required"
IF IBERR% = 6 THEN PRINT "I/O operation aborted"
IF IBERR% = 7 THEN PRINT "non-existent GPIB-PC board"
IF IBERR% = 10 THEN PRINT "I/O started before previous operation completed"
IF IBERR% = 11 THEN PRINT "no capability for operation"
IF IBERR% = 12 THEN PRINT "file system error"
IF IBERR% = 14 THEN PRINT "command error during device call"
IF IBERR% = 15 THEN PRINT "serial poll status byte lost"
IF IBERR% = 16 THEN PRINT "SRQ stuck in on position"
INPUT "[ENTER] TO CONTINUE"; A$' if help$ then
RETURN
' ***** TERMINATE PROGRAM *****
TERMINATE:
REMOTE% = 0
CALL IBSRE(GP%, REMOTE%)
PRINT "PROGRAM TERMINATED."
END

```

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MAINTENANCE

Introduction

This section of the manual provides information on changing internal fuses, and on obtaining instrument servicing.

Calibration/Adjustment

Instrument calibration should be checked every 6 months or after 1000 hours of use, whichever occurs first.

Adjustment of internal circuits to specified accuracy, and/or calibration check should be performed at the factory. Before returning your instrument for any servicing, please contact your nearest Tektronix Service Center.

Battery Replacement

When the instrument display indicates that internal battery power is low, please contact your nearest Tektronix Service Center to arrange battery replacement.

Internal Fuse Replacement—AFG 5501

WARNING

Before beginning this fuse replacement procedure, turn off the AFG 5501, and disconnect the power cord from the power source.

On the bottom front edge of the cabinet, remove the Phillips screw just to the left of the cabinet bottom seam, as you face the front of the AFG 5501.

Pull on both release latches on the front panel; the generator assembly should move forward, out of the cabinet. Remove the generator assembly.

The fuses are located under the cover on the right side of the AFG 5501 (as you face the front of the unit). The side cover snaps onto the metal rails. Along each long edge of the cover, there are cutouts about one-half inch in length. Insert tweezers or a small straight-edge screwdriver into the cutout near the back edge of the cover, and carefully pry the cover away from the metal rails. Remove the cover.

Three fuses are located toward the rear of the exposed circuit board, mounted in fuse holders. To remove a fuse, carefully pull it out of the fuse holder.

WARNING

To avoid fire hazard, use only the fuse of correct type, voltage rating, and current rating as specified in the Specification section of this manual.

After fuse replacement, re-install the side cover, as follows. Insert the front edge of the cover into the groove along the front edge of the unit. Then press the cover down over the rails.

To re-install the generator assembly, stand the cabinet up on its rear panel. Insert the assembly into the cabinet, taking care to align the assembly rear edge connectors with the connectors inside the cabinet. When these are aligned, press the generator assembly firmly into the cabinet to seat the connectors.

Reinstall the retaining screw in the bottom front edge of the AFG 5501.

Fuse Replacement—AFG 5101

Remove the AFG 5101 from the power module. The fuses are located under the cover on the right side of the AFG 5101 (as you face the front of the unit). The side cover snaps onto the metal rails. Along each long edge of the cover, there are cutouts about one-half inch in length. Insert tweezers or a small straight-edge screwdriver into the cutout near the rear edge of the cover, and carefully pry the cover away from the metal rails. Remove the cover.

Three fuses are located toward the rear of the exposed circuit board, mounted in fuse holders. To remove a fuse, carefully pull it out of the fuse holder.

WARNING

To avoid fire hazard, use only the fuse of correct type, voltage rating, and current rating as specified in the Specification section of this manual.

After fuse replacement, re-install the side cover, as follows. Insert the front edge of the cover into the groove along the front edge of the unit. Then press the cover down over the rails.

OPTIONS

The following options are available for the AFG 5101/5501.

AFG 5101 Options:

Option 02—adds an internal, frequency-lock synthesizer.

AFG 5501 Options:

Option 02—adds an internal, frequency-lock synthesizer.

The following are AFG 5501 power options:

Option A1—changes the power to Universal European (220 Volt, 16 Amp, 50 Hz).

Option A2—changes the power to United Kingdom (240 Volt, 13 Amp, 50 Hz).

Option A3—changes the power to Australian (240 Volt, 10 Amp, 50 Hz).

Option A4—changes the power to North American (240 Volt, 15 Amp, 60 Hz).

Option A5—changes the power to Switzerland (220 Volt, 10 Amp, 50 Hz).

REPLACEABLE PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

1 2 3 4 5 *Name & Description*

Assembly and/or Component

Attaching parts for Assembly and/or Component

**** END ATTACHING PARTS ****

Detail Part of Assembly and/or Component

Attaching parts for Detail Part

**** END ATTACHING PARTS ****

Parts of Detail Part

Attaching parts for Parts of Detail Part

**** END ATTACHING PARTS ****

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Attaching parts must be purchased separately, unless otherwise specified.

ABBREVIATIONS

"	INCH	ELCTRN	ELECTRON	IN	INCH	SE	SINGLE END
#	NUMBER SIZE	ELEC	ELECTRICAL	INCAND	INCANDESCENT	SECT	SECTION
ACTR	ACTUATOR	ELCTLT	ELECTROLYTIC	INSUL	INSULATOR	SEMICOND	SEMICONDUCTOR
ADPTR	ADAPTER	ELEM	ELEMENT	INTL	INTERNAL	SHLD	SHIELD
ALIGN	ALIGNMENT	EPL	ELECTRICAL PARTS LIST	LPHLDR	LAMPHOLDER	SHLDR	SHOULDERED
AL	ALUMINUM	EQPT	EQUIPMENT	MACH	MACHINE	SKT	SOCKET
ASSEM	ASSEMBLED	EXT	EXTERNAL	MECH	MECHANICAL	SL	SLIDE
ASSY	ASSEMBLY	FIL	FILLISTER HEAD	MTG	MOUNTING	SLFLKG	SELF-LOCKING
ATTEN	ATTENUATOR	FLEX	FLEXIBLE	NIP	NIPPLE	SLVG	SLEEVING
AWG	AMERICAN WIRE GAGE	FLH	FLAT HEAD	NON WIRE	NOT WIRE WOUND	SPR	SPRING
BD	BOARD	FLTR	FILTER	OBD	ORDER BY DESCRIPTION	SQ	SQUARE
BRKT	BRACKET	FR	FRAME or FRONT	OD	OUTSIDE DIAMETER	SST	STAINLESS STEEL
BRS	BRASS	FSTNR	FASTENER	OVH	OVAL HEAD	STL	STEEL
BRZ	BRONZE	FT	FOOT	PH BRZ	PHOSPHOR BRONZE	SW	SWITCH
BSHG	BUSHING	FXD	FIXED	PL	PLAIN or PLATE	T	TUBE
CAB	CABINET	GSKT	GASKET	PLSTC	PLASTIC	TERM	TERMINAL
CAP	CAPACITOR	HDL	HANDLE	PN	PART NUMBER	THD	THREAD
CER	CERAMIC	HEX	HEXAGON	PNH	PAN HEAD	THK	THICK
CHAS	CHASSIS	HEX HD	HEXAGONAL HEAD	PWR	POWER	TNSN	TENSION
CKT	CIRCUIT	HEX SOC	HEXAGONAL SOCKET	RCPT	RECEPTACLE	TPG	TAPPING
COMP	COMPOSITION	HLCPS	HELICAL COMPRESSION	RES	RESISTOR	TRH	TRUSS HEAD
CONN	CONNECTOR	HLEXT	HELICAL EXTENSION	RGD	RIGID	V	VOLTAGE
COV	COVER	HV	HIGH VOLTAGE	RLF	RELIEF	VAR	VARIABLE
CPLG	COUPLING	IC	INTEGRATED CIRCUIT	RTNR	RETAINER	W/	WITH
CRT	CATHODE RAY TUBE	ID	INSIDE DIAMETER	SCH	SOCKET HEAD	WSHR	WASHER
DEG	DEGREE	IDNT	IDENTIFICATION	SCOPE	OSCILLOSCOPE	XFMR	TRANSFORMER
DWR	DRAWER	IMPLR	IMPELLER	SCR	SCREW	XSTR	TRANSISTOR

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
16428	COOPER BELDEN ELECTRONIC WIRE AND CA SUB OF COOPER INDUSTRIES INC	NW N ST	RICHMOND IN 47374
70903	COOPER BELDEN ELECTRONICS WIRE AND C SUB OF COOPER INDUSTRIES INC	2000 S BATAVIA AVE	GENEVA IL 60134-3325
71400	BUSSMANN DIV OF COOPER INDUSTRIES INC	114 OLD STATE RD PO BOX 14460	ST LOUIS MO 63178
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON OR 97707-0001
S3109	FELLER	ASA ADOLF AG STOTZWEID CH8810	MORGEN SWITZERLAND
TK1373	PATELEC-CEM (ITALY)	10156 TORINO	VAICENTALLO 62/45S ITALY

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective Dscnt	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-	159-0107-00		2	FUSE, CARTRIDGE: DIN, 2A, 250VAC, TIME LAG	80009	159-0107-00
	159-0302-00		1	FUSE, CARTRIDGE: 1A SLOW, DIN METRIC	80009	159-0302-00
	161-0066-00		1	CABLE ASSY, PWR, :3, 18AWG, 115V, 98.0 L (AFG 5501 ONLY)	16428	CH8481, FH8481
	159-0019-00		1	FUSE, CARTRIDGE: 3AG, 1A, 250V, SLOW BLOW (AFG 5501 STANDARD ONLY)	71400	MDL 1
	161-0066-09		1	CABLE ASSY, PWR, :3, 0.75MM SQ, 220V, 99.0 L (AFG 5501 OPTION A1 EUROPEAN)	S3109	86511000
	159-0032-00		1	FUSE, CARTRIDGE: 3AG, 0.5A, 250V, SLOW BLOW (AFG 5501 OPTION A1)	80009	159-0032-00
	161-0066-10		1	CABLE ASSY, PWR, :3, 0.75MM SQ, 240V, 96.0 L (AFG 5501 OPTION A2 UNITED KINGDOM)	TK1373	24230
	159-0032-00		1	FUSE, CARTRIDGE: 3AG, 0.5A, 250V, SLOW BLOW (AFG 5501 OPTION A2)	80009	159-0032-00
	161-0066-11		1	CABLE ASSY, PWR, :3, 0.75MM, 240V, 96.0 L (AFG 5501 OPTION A3 AUSTRALIAN)	S3109	ORDER BY DESCR
	159-0032-00		1	FUSE, CARTRIDGE: 3AG, 0.5A, 250V, SLOW BLOW (AFG 5501 OPTION A3)	80009	159-0032-00
	161-0066-12		1	CABLE ASSY, PWR, :3, 18 AWG, 250V, 99.0 L (AFG 5501 OPTION A4 NORTH AMERICAN)	70903	CH-77893
	159-0032-00		1	FUSE, CARTRIDGE: 3AG, 0.5A, 250V, SLOW BLOW (AFG 5501 OPTION A4)	80009	159-0032-00
	161-0154-00		1	CABLE ASSY, PWR, :3, 0.75MM SQ, 240V, 6A, 2.5M L (AFG 5501 OPTION A5 SWITZERLAND)	S3109	86515000
	159-0032-00		1	FUSE, CARTRIDGE: 3AG, 0.5A, 250V, SLOW BLOW (AFG 5501 OPTION A5)	80009	159-0032-00
STANDARD ACCESSORIES						
	070-6759-00		1	MANUAL, TECH: INSTR, AFG5101/5501	80009	070-6759-00
	070-6761-00		1	MANUAL, TECH: REF GUIDE, AFG5101/5501	80009	070-6761-00
	070-6930-00		1	MANUAL, TECH: AFG5101/5501	80009	070-6930-00



MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

